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ECONOMIC GEOGRAPHY

JULY

ECONOMIC PROGRESS OF ST. VINCENT, B.W.I., SINCE 1927
Frederick Walker

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E. Ray Casto

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Preston Pilbin

CULTIVATION AND EXPORT OF NETHERLANDS FRUIT
Aage H. Kampp

CLARK UNIVERSITY, WORCESTER, MASSACHUSETTS, U.S.A.

OUR CONTRIBUTORS

Dr. Walker, lecturer in geology and geography at the University of St. Andrews, has done a great deal of research both in Scotland and abroad, and has published a large number of articles in geology and geography which attest to his scientific skill and integrity, and his breadth and depth of research. Originally interested in geology, his major recent work is in the field of geography, and the present paper indicates how thoroughly he has mastered the technique and discipline of his new choice.

Dr. Casto, professor of geography and geology at Emory and Henry College, Emory, Virginia, since 1920, received his Ph.D. at Clark University in 1926. During the summer of 1935 he was a member of the School of Oriental Research, Jerusalem, Palestine, and participated in extensive and intensive field studies of the Holy Land.

Dr. Taylor is well known throughout the world for his geologic, geographic, and anthropological studies. He served with the Mawson Australian expeditions to Antarctica. He has been member and head of the staffs of geography at the University of Sidney, and the University of Toronto, and has taught both at the University of Cambridge and the University of Chicago. His researches have led him into manifold fields of study, and his publications represent a multiplicity of interests and projects. He is a leader in several fields, always stimulating, always provocative of thought and discussion.

Dr. Primmer received his B.Ed. degree from Illinois State Normal University in 1921, his M.Sc. degree from Ogden Graduate School of Science, University of Chicago, 1923, and his Ph.D. from Clark University in 1933. He was student assistant in the department of geography at the University of Chicago in 1921–22. Teacher of geography at Duluth State Teachers College, Duluth, Minnesota, in 1922–32, and since 1933, head of the department.

Mr. Hoover has made the geographic relationships of the primitive tribes and cultures of the Southwest to the lands and resources in which they are native, the major field of his activity and research the last several years. His articles have been published in numerous magazines, and this contribution represents one of his latest research projects.

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Mr. Kampp, lecturer in economic geography at the People's International College at Elsinore, Denmark, has engaged in wide programs of agricultural research, chiefly in fruit growing in Holland and in Denmark, his particular field being the relationship of geographic factors to methods and yields of fruit production. He has studied under some of the most competent men in Denmark, among them Dr. G. Hatt and Dr. M. Vahl.

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TROPICAL ISLANDS

THE economic potentialities of tropical islands excite the imagination of the geographer, the merchant, the politician. They constitute ever a puzzle, a problem, a hazard of chance wherein fortunes may be made or lost, lives of millions enriched or debased. Constant in their attributes of location, relief, soil, and climate, their possibilities of crop or industry or port facilities, they vary in their resources and strength from century to century, from culture to culture, with all the waywardness of destiny. Where success attends the labor of their folk today, and wealth rolls in, tomorrow they find failure, unexpected and sudden, and poverty enters upon their hearthstones.

Thus has ever been the history of islands. Minos and Patmos, Rhodes and Sicily, each has its day, or days, in the sun of economic and political success, and then darkness of adversity falls. The water supply becomes polluted, pest or plague seizes upon some crop or source of food, the course of trade or empire changes its direction,—and the fate of an island is sealed!

The islands of the Antilles have shared the uncertain pattern of island fate. Piracy and plantation; shipwreck and golden fortune; disease and death, joy and vitality; sordid squalor and poverty, colorful plenty and excitement, these have followed in kaleidoscopic and unforeseen succession. Slavery and freedom, peace and poverty, plenty and ruthlessness—they have gone hand in hand down the startling pages of Antillean history.

What tales and memories these islands conjure up! Jamaica and the Barbados, St. Vincent and Martinique, Trinidad and St. Croix, Granada and the Isle of Pines, Cuba and Grand Cayman, Curacao and Great Inagua, Aruba and Dominica, Blanquilla and Guadeloupe—these and a hundred more names, lend romance and fantasy and mystery to their geography and political relationships.

ECONOMIC GEOGRAPHY

VOL. 13 JULY, 1937 NO. 3

ECONOMIC PROGRESS OF ST. VINCENT, B. W. I., SINCE 1927

Frederick Walker

IN 1929, an article by Mr. G. Wright entitled "Economic Conditions in St. Vincent, B. W. I." appeared in ECONOMIC GEOGRAPHY and gave a full account of the various industries of the island. It might seem, therefore, that any contribution on a similar subject, written after a lapse of only eight years, might run the danger of being redundant. It need not be so, however, for during this short period the island, in company with all the other agricultural islands of the West Indies, has been hard hit by the world depression, which overtook them in 1931, and from which they are now slowly recovering. St. Vincent has been particularly successful in weathering the storm, but only by drastic reorganization of its basic industries. The nature of the reorganization is of particular interest to the geographer, since two of the crops are practically monopolistic, and is described below. The chief changes since 1927, the last year for which Mr. Wright gives statistics, have been:

(1) The formation of the St. Vincent Arrowroot Association in 1930, with grading and coöperative marketing schemes, and the resultant growth of the arrowroot industry which now provides the chief export crop of the island.

(2) The marked decline of the Sea Island Cotton Industry from its position as chief export crop in 1926, and its gradual recovery under the supervision of the Cotton Research Station.

(3) The decline of the sugar, molasses, and syrup industries.

(4) The replacement of the export of copra by that of whole coconuts.

(5) The decline of the cacao industry.

(6) The establishment of a promising tomato export industry and its almost total disappearance since 1932, a year of very low prices.

(7) The commencement of a rapidly growing banana export industry in 1935.

In addition, important soil surveys and entomological investigations have been made with the aid of the Imperial College of Tropical Agriculture in Trinidad, and there has also been a marked increase in the amount of climatic data published since 1930, rainfall records being now available from stations on both sides of the island.

The recovery of the island has been hastened by the aid of a very active Agricultural Department which, in its turn, is under the supervision of the Imperial College of Agriculture and can obtain expert advice from specialists in this institution when necessary.

TOPOGRAPHY AND GENERAL ASPECT

St. Vincent (13° 10′ N., 60° 57′ W.) is a volcanic island measuring 18 miles (N.–S.) by 11 miles (E.–W.) and form-

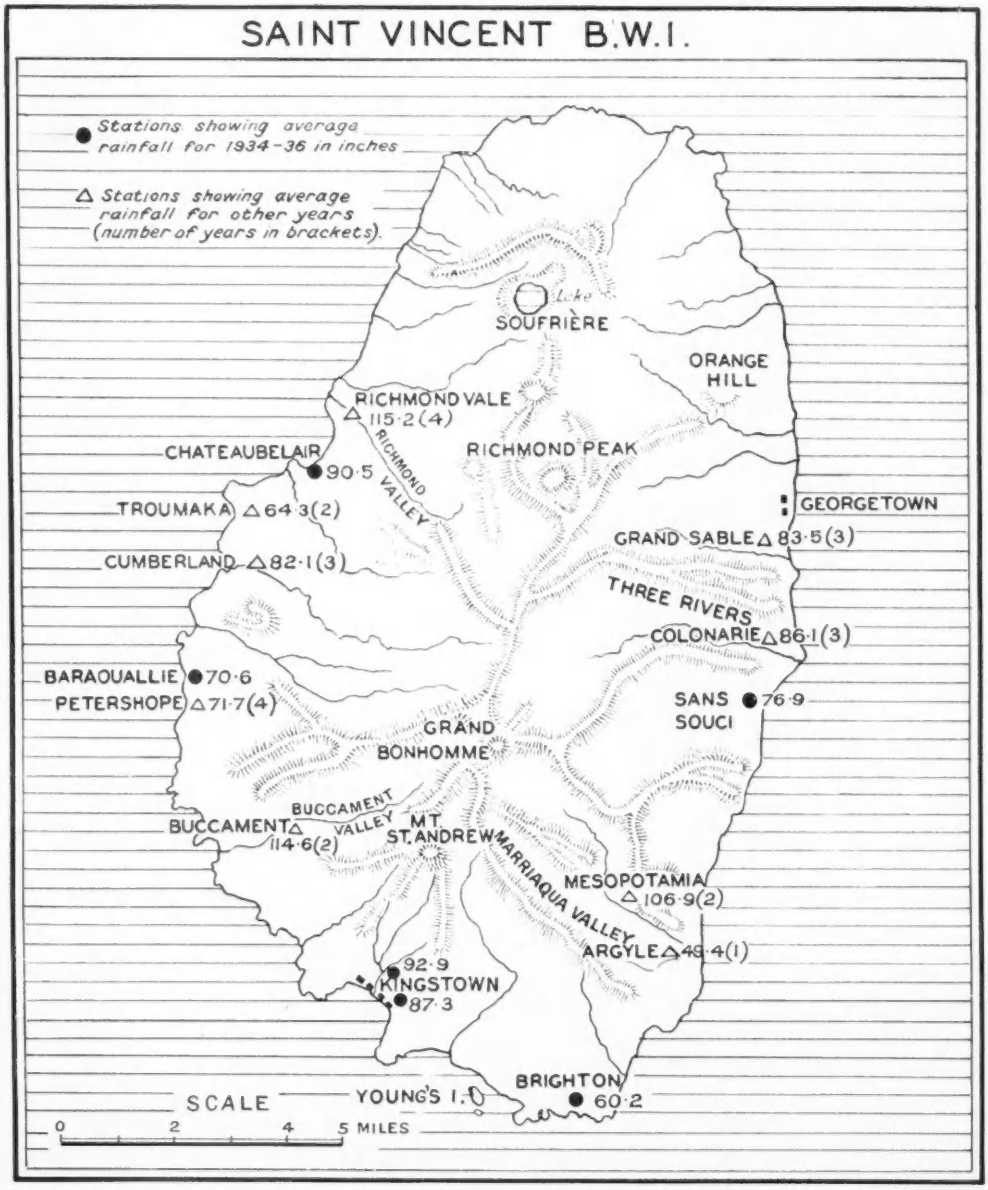

FIGURE 1.—St. Vincent Island, like so many other of the islands, shows a longitudinal mountain axis from which lateral spurs, simple or multiple as the case may be, extend in all directions. Diversified relief on the island creates diversified climatic conditions and makes most of the Caribbean islands interesting subjects of geographic study.

ing one of the Windward Islands in the chain of the Lesser Antilles. The area of the main island is 130 square miles, but a number of the group of small islands known as the Grenadines, lying between St. Vincent and Grenada, are included with the former island for administrative purposes. Their total area is 17 square miles.

The chief topographical feature of St. Vincent is a long, high, axial ridge running north to south and dividing the island into two almost equal parts known as the "windward" and the "leeward"

sides from their orientation with regard to the northeast trade winds. Soufrière (4,000 feet), Richmond Peak (3,539 feet), Grand Bonhomme (3,193 feet), and Mount St. Andrew (2,433 feet) are the chief peaks of this ridge from north to south, the highest one, Soufrière, being an active volcano which spread desolation over the northern portion of the island by violent eruptions in 1902 and 1903. From this central ridge others branch off both east and west. Those on the leeward side (west) are sharp and steep so that the valleys of this side are on the whole narrow, deep, and picturesque. Those of the windward side are more gently sloping and the topography generally is considerably more open. The northern end of the island is still smoother as a result of the vast masses of fragmental material ejected during the recent eruptions of Soufrière.

A series of terrace-like raised beaches at various levels up to 700 feet characterizes the windward slopes of the island, one at 200 feet being very persistent, but they are poorly developed on the leeward side owing to the relatively small amount of marine erosion. The rivers of the island are short and straight. Although their upper portions may run in narrow gorge-like valleys, these broaden out near the mouths to show small delta-like flats of alluvial material which are well-marked in the leeward valleys. The windward valleys are usually much wider and occasionally merge into extensive coastal plains. No deep indentations occur along the coast line.

The island as a whole presents a thickly wooded aspect, and three definite zones of vegetation have been recognized:

(1) A lower zone, below about 1,500 feet, now largely cultivated, but which appears to have been dominated originally by Arocomia

FIGURE 2.—Distinctly Antillean in its character, the valley is typical of almost the whole group of the several widely scattered islands of the Caribbean Sea.

palms and consisted of the drier type of rain forest.

(2) A moist rain forest belt beginning at about 1,500 feet which may, however, follow down the deep leeward valleys to 400 feet.

(3) Beginning at about 2,000 feet, a belt of scrub passes upwards into an alpine fell-field zone with herbs and other low plants.

Cultivation is confined for the most part to the first and lowest of these zones and covers about 60 per cent of the island.

CLIMATE

In some respects the climate of St. Vincent is of the hot, moist, equatorial type, in others it is more of a tropical nature. The latitude of the island (13° 10′) is sufficiently far north to allow the influence of the northeast trades to be strongly felt during the relatively dry winter, but the northerly swing of the equatorial convectional rains gives a well-marked wet summer season. The warm surface waters of the Caribbean have an equalizing effect on the temperature, restricting the annual range to 3.7°F. (Kingstown), but the diurnal range of about 10° is usually sufficiently great to render the nights pleasantly cool, especially as the humidity is comparatively low, due to the great porosity of the soil and resultant lack of evaporation of surface water. The absolute maxima and minima recorded are 89° and 60°, but temperatures above 87° or below 68° are very rare. The mean annual temperature is 80.1°.

Until 1930 the only published meteorological records were those of the Botanic Gardens and the Experiment Station at Kingstown, the former of rainfall alone and the latter of temperature and humidity as well. Since that year, however, there has been a welcome increase in climatological data, and rainfall records are now taken at several stations on either side of the island. Unfortunately, there are gaps in their readings which are therefore of small use for comparative purposes, but six stations have more or less complete records over the last three years. A digest of all the rainfall records is shown on the sketch-map.

Detailed examination of the available data of rainfall shows that the average annual precipitation at the recording stations varies from 60 inches to 115 inches, but none of the stations with records for over three years is far removed from the coast. The lowest reading is from a station with an open situation in the extreme south and the highest from an estate in the narrow and steep-sided Buccament Valley on the leeward side. In general, stations on the windward coast are drier than those on the leeward, but examples in relatively open country on the leeward coast (e.g. Peters Hope) show readings comparable with those of the windward side. The heaviest recorded precipitation seems to occur in the deeper of the leeward valleys where the hot, moist airs of summer are trapped and forced to ascend. No records of high level stations are available, but it is obvious to the observer that the precipitation is heavier on the mountains. Not only is the mountain vegetation characteristic of a moister climate, but numerous showers fall there which leave the coasts untouched. The small rainfall map published in Cutteridge's "Geography of the West Indies," though constructed without data, is probably quite near the truth. An accurate rainfall map is still impracticable.

St. Vincent is sufficiently near the equator to show a faint summer double maximum in its rainfall records, but precipitation is well enough distributed for severe droughts to be rare even in the dry winter season (January–July). The majority of years show a well-

marked double maximum individually, but the time of its incidence is so variable that it becomes faint in any average. The mean humidity is about 70 (though it may rise to almost 80 in summer) and this, combined with the constant northeast trades and the absence of standing water, renders the winter climate of the island one of the healthiest and most delightful in the West Indies. St. Vincent lies within the hurricane belt, but it is now sixteen years since a severe hurricane visited the island.

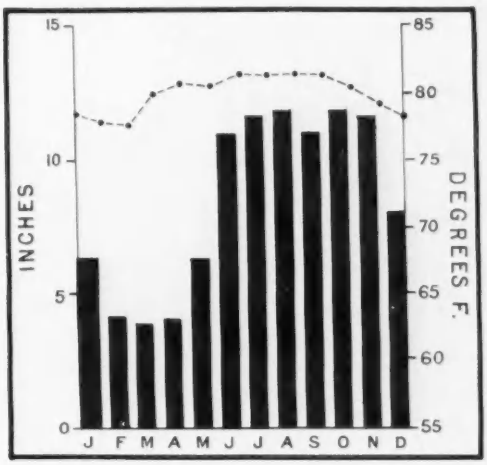

FIGURE 3.—Climatic Chart. Kingstown, St. Vincent, B. W. I. Latitude 13° 9′ North; Longitude 61° 14′ West; Elevation 90 feet. Average Annual Temperature between 80° and 81° F.; Average Annual Precipitation 103 inches. Length of Record—Temperature 10 years; Precipitation 30 years.

GEOLOGY

The geology of St. Vincent is very simple, for almost the whole of the island consists of volcanic ash and occasional lava flows and minor intrusions of hypersthene andesite and olivine-basalt. The north of the island is completely covered by agglomerate and tuff from the active volcano Soufrière, which last erupted in 1903 but has emitted no lavas in historic times. In 1902–03 the eruptions were of the highly destructive *nuée ardente* type and did immense damage to life and property, almost wiping out the Carib population of the island. In this class of eruption a heavy black cloud, charged with incandescent volcanic dust, rolls down the mountain side overthrowing and burning everything in its path. The material ejected during these and earlier eruptions is of a sandy or cindery nature without many large fragments. Much of the recent deposit has been washed down towards the sea by torrential rainfall, resulting in the formation of "dry rivers" (of bare ash) on both coastlines. Although the freshly erupted ash was exceedingly infertile, cultivation was soon reëstablished (in less than a year on some estates) by trenching through the recent deposits and mixing them with the older soils whose fertility had been temporarily increased by heat sterilization of destructive microörganisms. By 1912, luxuriant green vegetation again clothed Soufrière to a height of 2,000 feet and ferns and mosses were to be found within the new crater.

South of Soufrière the volcanic deposits are older, have undergone considerably more erosion, and show more variety. The fragmental material is more compact and comprises, besides ash of Soufrière type, many layers of agglomerate with boulders of large size (including plutonic types such as anorthosite and norite) and there are also numerous lava flows. No vent has yet been discovered from which these rocks might have been erupted, though the basin-shaped Marriaqua Valley in the south of the island may possibly represent the site of a caldera. The lava flows are occasionally columnar and may form prominent features either on the coastline or valley sides. They vary in thickness from 40 to 200 feet. The andesitic types appear to be the older and are confined to the south of the island. Lavas and sills of basalt are newer and are intercalated among the fragmental

deposits from which they are distinguished with some difficulty, when the latter are compact and massive. All the above formations, whether fragmental or truly igneous, combine in showing a low inclination towards the sea, with the exception of a few dikes recorded by the writer on the coast opposite Young's Island in the extreme south. In this neighborhood there are also one or two small fringing coral reefs which represent the only sedimentary formations of St. Vincent.

SOIL

A very thorough investigation of the "agricultural soils of St. Vincent" was made in 1934 under the auspices of the Imperial College of Tropical Agriculture, Trinidad by Messrs. F. Hardy, C. K. Robinson, and G. Rodriguez. Forty-two profiles were examined and sampled, yielding 319 soil samples. Experiments carried out on this material led to the following conclusions:

The soils of St. Vincent fall into three chief groups.

I. *Yellow Earth Soils* derived from andesitic and basaltic agglomerate, ash and lava.

II. *Alluvial Soils* occurring in Coastal Plains and Valley Deltas.

III. *Recent Volcanic Ash Soils* derived from fragmental material ejected by Soufrière in 1902–03.

The soils as a whole are characterized by:

(a) Immaturity, as indicated by: (i) High contents of unaltered mineral grains (particularly in the case of group III; (ii) Marked vertical uniformity (except where old buried soils occur); (iii) Grey pale brown or yellow colors; (iv) Low contents of colloidal weathering products;

(b) High permeability to water, due to their sandy nature;

(c) Medium high contents of organic matter (0.5–5.5 per cent) which penetrates deeply;

(d) Neutral to slightly acidic reaction;

(e) Low rate of solution of the mineral components;

(f) Variable, though relatively low, contents of available phosphate and potash;

(g) Low saturation capacity and low contents of exchangeable bases, but a high degree of saturation by bases.

Manurial experiments have also been undertaken in connection with this investigation and indicate that the organic matter in the soil plays an important part in its fertility by supplying nutrient elements (particularly nitrogen) during decay and (less certainly) by assisting the solution of soil minerals through formation of carbon dioxide by oxidation. Experiments carried out on cotton and arrowroot crops show marked improvements in yield by addition of nitrogenous manures. Nitrogen is probably the element most deficient in all the soils and is best supplied by fertilizers somewhat less readily soluble than the ammonium sulphate which is commonly employed.

LAND OWNERSHIP AND LABOR

A full account of land tenure, land settlement and labor in St. Vincent has been given by Mr. Wright, so the writer will confine himself to the recent developments which have taken place.

Visitors to the island at the present day cannot fail to be impressed by the abject poverty of a great part of the negro population outside the capital town Kingstown. That this impression is a true one is indicated by the following

table which shows the annual trade in £s sterling per capita for some of the West Indies islands in 1935.

TABLE I

TRADE PER CAPITA IN £S STERLING FOR THE YEAR 1935

Martinique	30 (approx.)	Montserrat	9.75
Porto Rico	18 (approx.)	Antigua	9.60
Barbados	16.09	Grenada	6.45
St. Kitts—Nevis	13.51	St. Vincent	5.71
Trinidad—Tobago	10.09	St. Lucia	4.82
		Dominica	3.64

The significance of these figures is perhaps better realized when it is stated that 30,000 acres, or more than half the best cultivable land, is divided among 30 large estates. The number of peasant landowners is 2,763, of whom 2,614 possess areas of from 1 to 10 acres. In December, 1935, the estimated population of the island was 55,219, of whom about 70 per cent were negroes and 4.5 per cent white.

There is, in fact, a very unequal distribution of wealth in the island and the standard of living of the negro laborer is exceedingly poor, in spite of a genial and productive climate.

Land Settlement. The land settlement schemes initiated by Government in 1899 have been described by Mr. Wright. Since that year 8,249 acres have been purchased by Government for distribution among small-holders. One of the principal obstacles encountered is the difficulty of obtaining a rental from the settlers sufficient to recoup the Government for the expenses of purchase. This is due to the fact that wages paid to agricultural laborers in the island are so low that it is almost impossible for them to save enough to meet the instalments due on the lease or purchase price. Large arrears of payment have thus accumulated and the Government has incurred loss on the transaction. A solution to this problem may be found by extending the payments over a larger number of years.

In the Three Rivers Land Settlement scheme initiated in 1933, there were 132 allotments for distribution amounting to 631 acres. After a year little more than half the land had been taken up. By reducing the deposit from 20 per cent to 10 per cent, however, the remainder of the land was disposed of much more rapidly. This would indicate that there is a real demand for land provided the price is within reach of the would-be settlers, which is scarcely surprising, for the various coöperative factory and marketing schemes started in the island all react to the advantage of the small holder.

The working of the Three Rivers scheme may be regarded as fairly successful, for few of the purchase instalments are now in arrears. Moreover, the arrowroot and syrup factory owned by the Government and leased to an Agricultural Credit Society (formed in 1934 in connection with the scheme) at a nominal rental shows a satisfactory working profit over the year 1935. It is probable that other schemes, similarly organized, would meet with equal success and do much to alleviate the poverty of the peasant population. They are not likely, however, to receive the support of the large estate owners who see in them a future shortage of estate labor.

Wages. Mr. Wright (1929) states that the average wage paid to agricultural laborers for a task of five to six hours was one shilling (24 cents) and the Annual Colonial Report for 1935 gives the amounts as eightpence to one shilling (16 to 24 cents) for the same work. The writer found, however, that payments are generally much lower, being tenpence to one shilling a day of eight to nine hours for men and sixpence to eightpence for women. On some parts of the leeward coast even lower wages are paid.

The Government has this year fixed a much needed minimum wage of one

shilling and twopence a day for men and tenpence a day for women, both for a day of eight to nine hours. This should certainly react to the benefit of the laborer, but it will probably result also in the discharge of elderly and inefficient workers and the suspension of some of the privileges (e.g. free bread fruit) which are at present enjoyed. A difficulty yet to be surmounted is the seasonal character of most of the labor required.

Housing. The housing of much of the peasant and laboring population of the island is deplorable, their minute mud and wattle huts being more reminiscent of savage African tribes than of a relatively civilized Christian community. Efforts have been made by Government to provide adequate housing, but, here again, the extreme poverty of those most requiring new houses has proved a difficult obstacle, as an account of the most recent attempt in this direction shows clearly. One hundred concrete houses were erected by Government in 1932, fifty at Georgetown and fifty at Chateaubelair. At the former village, though all but two were occupied in December, 1936, over £200 arrears of purchase money have accumulated, much of which is irrecoverable. At Chateaubelair the situation is worse, for twenty-seven houses are vacant and £300 is due from tenants who have been ejected for failing to meet their instalments. The purchase money for each house was £55, payable in twenty-five yearly instalments together with interest.

A suggestion made by the present administrator, His Honour A. A. Wright, C.M.G., in his address to the Legislative Council of the island is likely to prove more feasible. It is that a subsidy be paid to each man erecting (with the aid of demonstrators) a house of a standard approved pattern on his own land and for the use of his own family. The prevention of overcrowding, with the inevitable large percentage of illegitimate births, is the chief matter to be considered and the nature of the building material is of secondary importance. Regulations governing the erection of new houses have recently been passed by the Sanitary Authority and this should have a beneficial effect on the health of the negro population. The minimum requirements now insisted upon are: a plot of land 75 feet by 50 feet; two rooms of 64 square feet each; a height of eight feet from floor to plate; pillars 2 feet off the ground; ventilation openings equivalent to 1/10 of the floor space; and a latrine. Over 1,000 applications for houses have been approved since the introduction of these regulations in 1930 and a large proportion has been completed, mostly by the work of their prospective inhabitants.

Standard of Living. The low wages current in St. Vincent and the seasonal character of most of the work makes for a correspondingly low standard of life among the laboring population. Malnutrition is not generally obvious in such a healthy and productive climate, but it is significant that in spite of a low death rate of 15.3 per thousand (1935) the deaths attributable to worm affections amounted to no less than 10.24 per cent of the total. Poverty of the negro population is clearly shown by the ragged and makeshift nature of their garments, and it is thought that many poor children forego the benefits of primary education (which is free, though not compulsory) through lack of the minimum clothing whereby they may retain their self-respect.

The above observations apply to outlying villages and not to the capital Kingstown, where conditions are much better. Here there is a widely utilized electric light system (extended this year to Calliaqua) and many of the outward signs of relative prosperity.

TABLE II

TYPE AND VALUE OF EXPORTS FROM ST. VINCENT IN £S STERLING (1928–35)

	1928	*1929*	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*
[1] Sea Island Cotton	28,459	24,261	30,377	25,463	8,392	8,107	9,346	9,947
[1] Marie Galante Cotton	1,358	2,373	2,523	704	1,417	1,619	1,123	804
Cacao	2,267	2,998	2,928	2,390	1,332	1,141	894	915
Arrowroot Starch	64,508	59,563	59,019	44,915	47,524	55,510	75,044	76,668
Cassava Starch	3,272	4,596	4,668	3,662	3,241	3,110	3,081	4,124
Sugar	14,190	14,095	9,209	5,100	1,900	8,162	5,979	6,406
Syrup and Molasses	12,058	13,063	13,937	8,380	5,994	11,624	11,218	6,162
Rum	.....	179	977	1,019	1,525	1,475	908	641
Coconuts	113	502	273	366	281	38	2,538	10,215
Copra	12,543	11,396	11,312	7,755	11,426	8,978	6,551	3,418
Peanuts	4,176	4,486	3,610	591	378	368	83	98
Maize	299	239	210	72	52	8	109	25
Peas	877	1,673	1,816	385	545	754	377	624
Nutmegs	709	764	1,120	281	151	342	269	378
Mace	398	623	800	229	139	301	210	283
[2] Fruit	209	393	510	550	626	524	563	403
Tomatoes	.....	5	146	545	1,763	250	146	85
Sweet Potatoes	2,395	2,474	1,527	1,766	1,101	2,185	3,152	2,294
Plantains	421	157	81	282	74	181	484	295
Tannias	422	351	385	553	334	519	607	477
Yams	.....	98	248	198	40	83	160	168
Bananas	66	67	58	92	51	37	46	475
Livestock	5,497	4,569	4,626	4,250	5,069	5,094	4,884	5,332
Poultry	382	445	520	399	491	820	770	687
Draft Animals	1,052	307	211	68	541	512	470	165
Hides	412	417	277	209	207	170	147	218
Total exports	158,472	151,570	149,704	113,165	97,299	119,130	135,229	134,922
Total imports	192,476	186,439	200,830	177,492	149,289	148,647	163,035	171,392

[1] Raw. [2] Excluding Bananas.

TRADE

Table II gives the principal exports of St. Vincent and the total imports since the period dealt with by Mr. Wright and, while the restrictive effect of the world depression is only too obvious, the satisfactory economic recovery of the island is equally noteworthy. This recovery was continued through 1936, for the total exports for the ten months ending October 31 amounted to £138,168, or £3,246 more than the total for the whole of 1935. The finances of the island have always been sound and revenue has almost invariably shown a small surplus over expenditure.

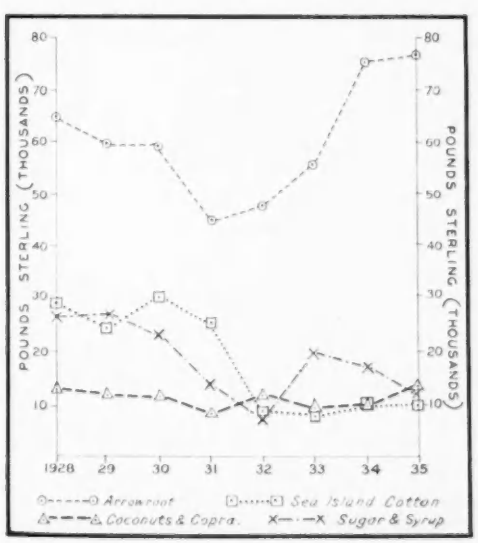

FIGURE 4.—Value of principal exports from St. Vincent, 1928–35. Arrowroot has occupied the first position in value and has contributed the major national income, even though it has fluctuated from year to year. Sugar and syrup have remained fairly constant in value. Sea island cotton has declined, as have coconuts and copra.

An account of the progress of some of the main industries through this interesting period is given below:

Arrowroot. Since 1927, the progress of the arrowroot starch industry has been almost continuous. Not only has the value of this product been least affected by the economic situation, but it has climbed into its rightful position as the premier export of the island and has opened out increasing markets in the United States in spite of the great severity of the economic depression in that country.

This happy result has been largely achieved by the formation, in 1930, of the St. Vincent Arrowroot Association

which deals with all the arrowroot produced in the Colony. The objects of the Association are:

(a) To acquire and market all arrowroot produced in the Colony and intended to be exported therefrom.

(b) To grade, pack, and warehouse arrowroot and to make advance payments on all arrowroot delivered to the Association warehouses.

(c) By means of voluntary control to market the crop more economically and thus reduce the cost for the consumer.

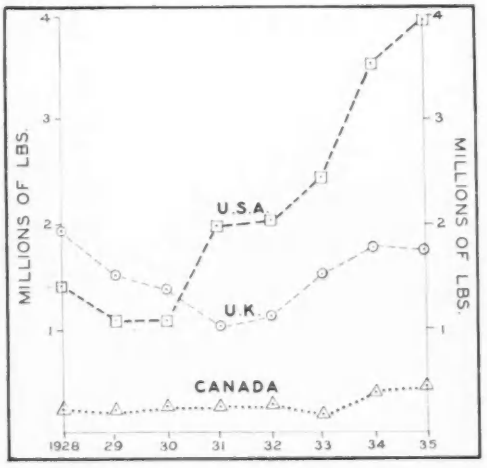

FIGURE 5.—The amount of arrowroot imported by the U. S. A. as compared with the United Kingdom and Canada for the years 1928–35, showing how the use of arrowroot has increased in the United States since 1930.

The erection of the necessary warehouses, with their blending and packing plants, was accomplished by a grant of £33,000 from the Colonial Development Fund, of which £30,000 was a loan bearing interest.

Grading is carried out by the manager of the Association by visual means, there being no other method available. Five grades are recognized: (1) extra superfine, (2) superfine, (3) fine, (4) good, (5) fair,—and advances are made to the growers of 3½, 3, 2½, 2¼ and 2 cents per lb. for the five respective grades. Small producers receive an advance of 25 per cent in addition.

As Mr. Wright has explained, the very pure water of St. Vincent gives the arrowroot industry an almost monopolistic natural advantage which the Arrowroot Association by intelligent marketing and unremitting efforts towards securing a uniform product has been able to exploit to the full. The graph, Figure 5, shows how greatly the export to the United States has increased in recent years, the amount taken by Britain remaining relatively constant. This is mainly due to new uses being found for the product by bakers and confectioners in the United States, but perhaps also to the more considerate treatment given to the Association by the American importers. Producers in St. Vincent were emphatic on this last point and bitter complaints were uttered about the methods of British importers. A notable drop in exports to Barbados and Trinidad after the formation of the Association indicates the elimination of a somewhat unnecessary re-export trade, but this has recently been resumed.

The methods of cultivation and production of arrowroot have not changed to any extent since 1927 and yields still average about 8 barrels of 220 lbs. per acre. The proportion of starch extracted is also low (15–20 per cent out of the 28–30 per cent available), but the quality of the starch has greatly improved and the percentage of Grade 2 arrowroot produced is now much higher, 33 per cent more was produced in 1936 than in 1935. This grade, incidentally, finds the best market. Modern machinery has been introduced into several factories and, with greater attention given to cleanliness of manufacture, there is now a very healthy spirit of competition at work in the island. The industry is, in short, a striking example of

the success of coöperative marketing. The estimated area under arrowroot in 1936–37 is 3,700 acres.

Manurial experiments are being carried on by the Arrowroot Officer of the Agricultural Department and have already been of considerable benefit to the yields of larger producers. Many of the peasant producers, however, are unable to afford the necessary fertilizers. The results of the manurial experiments, already completed, indicate the marked efficacy of a nitrogenous manure such as pen-manure plus ammonium sulphate and only a slight response to fertilizers containing phosphate or potash. There seems still considerable room for improvement in the methods of manufacture.

The principal trouble experienced by arrowroot growers is the occurrence of the long, tapering, fibrous rhizomes known as "cigar-roots." These abnormal rhizomes, besides being tough and difficult to break, are deficient in starch, the ratio of starch to fibre being less than eight in place of the normal 25. They are most abundant in fields which have undergone prolonged ratooning and have not been replanted for many seasons. Recent experiments, both in the laboratory and in the field, seem to show that this abnormality is due principally to potash deficiency in the soil, particularly in relation to nitrogen supply. The remedy is thus obvious, but must be preceded by replanting of the affected field. The ravages of the arrowroot worm (*Calpodes ethlius*) are occasionally troublesome and various forms of biological control have been suggested against this pest which has many natural enemies.

FIGURE 6.—Harvesting a field of arrowroot at the Experimental Station at Kingstown. The digging is a slow laborious process, but yields heavy returns.

Cassava. The cassava starch industry is very closely akin to arrowroot production, for the same methods of cultivation and factory preparation are employed. Its relatively small importance is due to the lower price obtainable for a finished product manufactured at almost the same cost as arrowroot. The export goes mainly to Trinidad and Barbados from which it is reëxported, but there has lately been some interest shown by Canada.

TABLE III

PRODUCTION OF SEA ISLAND COTTON IN ST. VINCENT SINCE 1927

Year	Area Planted Acres	Weight of Lint Lbs.	Yield of Lint Lbs. per Acre	Value of Export £	Price per Lb. of Lint Cents
1927–28.....	3,364	328,188	97	28,549	52
1928–29.....	3,386	263,808	79	24,261	52
1929–30.....	1,758	262,382	150	30,377	52
1930–31.....	3,955	605,280	153	25,463	24–48
1931–32.....	1,802	209,505	116	8,392	28
1932–33.....	669	85,852	122	8,107	28
1933–34.....	1,216	99,750	82	9,346	28–32
1934–35.....	1,464	173,600	119	9,947	29–36
1935–36.....	3,540	396,800	112	.....	40

Cotton. The figures in Table III tell a large part of the checkered history of the Sea Island Cotton industry since 1927, but not all. They show how the large acreage and abundant crop of 1930–31 came just before the world depression, leading to glutted markets and a disastrous fall in price. They show, further, that the industry is once again on the up-grade, but do not tell how this has been accomplished.

In 1927, the Sea Island Cotton industry of St. Vincent was in a fairly prosperous position in spite of a recent decline in the value of the exports. The Cotton Research Station had, however, been closed down in 1926. At this time two strains of Sea Island Cotton were grown—BD which closely resembles the variety now grown in Montserrat and has a relatively coarse staple averaging 51 mm. in length; and V135, the superfine cotton grown in St. Vincent today, with a strong silky staple of 58 mm. average length. These two strains had been kept pure up till 1926 by careful work at the Cotton Research Station, but by 1930 so many complaints had been received from the spinners in England of the quality of the lint, that an investigation was made in St. Vincent and the Cotton Research Station re-opened in 1930 upon the recommendation of the Imperial College, Trinidad. The two strains had crossed in many cases and their re-purification occupied two years. It was thus decided to grow only the superfine V135 in St. Vincent and this policy has been pursued ever since, though successful efforts have been made by the Cotton Research Officer to improve the yield of lint by crossing with selected plants of more prolific strains.

The world depression hit the Sea Island Cotton producers of the West Indies so hard that a Conference was called in Barbados in 1932 to discuss the situation. It was then decided to continue the growing of Sea Island Cotton, but to adopt restrictive measures and to advertise the product as much as possible. This policy has met with some success

FIGURE 7.—Cotton fields on the southeastern coastal plain. The large number of persons employed in picking the crop is indicated by the crowd in the fields. Cotton occupies the low, level, alluvial lands of the plain.

and further conferences have been held annually since 1932.

The superfine and costly V135 cotton of St. Vincent will probably never command a very large market, but the industry seems well on the way towards regaining some of its former prosperity, the estimated acreage and crop for 1936–37 being 5,000 acres and 440,000 lbs. of lint. At the time of writing the demand for V135 actually exceeds the supply.

The methods of cultivation and ginning are those described by Mr. Wright and the Government Ginning Factory continues to operate successfully. A change has been made in the planting season, however, which now lasts from August 1 till early October. There is an unfortunate tendency to prolong the planting season, for it is best restricted to a short period, from August 20–September 14, in order to mix the pests. Picking lasts from late December until the end of March.

Manurial experiments have shown that the best yields are given by a nitrogenous fertilizer such as ammonium sulphate to the amount of 3 cwt. per acre, but this is usually impracticable except on large estates. The peasant grower generally contents himself with adding the cotton seed meal returned to him by the ginning factory. Under optimum conditions, yields of 600 lbs. of lint per acre can be obtained. In 1934–35, 30 large growers in St. Vincent had 800 acres under cotton, while 844 peasants accounted for only 570 acres. A small amount of V135 cotton is also grown on the northern Grenadines, but the more southerly of these islands, being too dry for Sea Island Cotton to thrive, grow in preference the relatively inferior perennial Marie Galante Cotton, the export of which is declining.

It is unlikely that any country will attempt to oust St. Vincent as a grower of superfine Sea Island Cotton, for the demand is small and St. Vincent with its high rainfall and low humidity has great natural advantages. There is always the danger, however, that the high price of the product will turn the attention of manufacturers to the relatively inferior, but much less costly, Egyptian Sakel Cotton as a substitute.

FIGURE 8.—Factory for the processing of syrup and muscovado sugar near Argyle. This small factory with its modern equipment produces a good quality of centrifugal muscovado sugar used locally, but nearly all the factories in the island manufacture fancy molasses which finds a ready market in Canada and the United States.

The worst pest affecting cotton in St. Vincent is the cotton stainer (*Dysdercus delauneyi*). It is kept down somewhat by a rigid close season and by the destruction of alternate hosts, but Dr. Myers has suggested biological control by means of the Tachinid parasite (*Acaulona*), which has proved most useful in Peru. The pink boll-worm, another troublesome pest, is kept down by the same means.

Sugar and Syrup. The export figures (Table II) show the sugar and syrup industry to be a declining one, for, as previous writers have pointed out, the rugged topography and immature soil of the island are unsuited both to the cultivation of the sugar cane and to the establishment of large centrals. The small modern vacuum-pan sugar factory on the windward coast with its distillery has a fairly steady production and export of crystal sugar and rum, but the

acreage under sugar cane has declined to about 1,600 acres in 1936–37. With the exception of the factory mentioned above and another small factory with modern plant producing a good quality of centrifugal muscovado sugar used locally, all the factories in the island turn their attention to the production of fancy molasses, which finds a market in Canada and the United States. It is used largely in lumber camps.

Complaints by buyers of lack of uniformity in the export product have hampered sales of late, and it seems probable that the syrup industry may suffer a further decline until this defect is remedied, for stocks are accumulating alarmingly at present. Nearly all the factories, except the two mentioned above, are primitive and inefficient in the extreme, the syrup being concentrated in open taiches of iron after a somewhat sketchy clarification. Cleanliness of working, moreover, is generally conspicuous by its absence.

In spite of these faults, however, the sugar cane industry is a useful one to the island for two reasons—first, it necessitates the employment of labor throughout the year and second, it tends to prevent soil erosion. In both these respects it shows marked advantages over the rival crops of arrowroot and cotton. For these reasons the Agricultural Superintendent has recommended its continuance and it is possible that efforts may be made to erect an adequate blending plant for the preparation of export syrup, if financial aid can be obtained from the Colonial Development Fund.

FIGURE 9.—The drying of copra engages the attention of many workers and requires some little skill and experience. Relatively, copra plays a much smaller part in the export trade of the island than it did ten years since.

Not only is the process of syrup manufacture crude and antiquated, but the cultivation of the cane itself leaves much to be desired. The three best varieties grown are BH 10/12 (in wet districts), B 29/35 (in dry districts), and B 726, the last-named having a high sucrose content. Yields are poor, ranging from 15–18 tons per acre. This is due mainly to lack of manure, the growth of non-standard varieties and prolonged ratooning. Pests are not particularly abundant, but a recent entomological investi-

gation by Dr. J. G. Myers showed that the average infestation of joints by moth-borers (*Diatraea saccharalis* and *D. canella*) was 8.8 per cent on the leeward side and 6.6 per cent on the windward. Biological control by means of suitable Tachinid parasites is suggested as a remedy, as in the case of the cotton stainer.

Coconuts and Copra. The area under coconut palms in St. Vincent is upwards of 5,000 acres (5,235 in 1931) and shows little variation, for the products of this tree form one of the most stable exports of the island. Over half this acreage (3,000 acres) is accounted for by the large Orange Hill estate at the north of the windward coast where the palms flourish on the recent ejecta of Soufrière, but the tree is grown all over the island, since it needs little attention and the quality of the nuts is excellent.

The export figures of coconut products from the island since 1927 bring out at least one interesting feature. By 1934, the price of copra in London had dropped to £9 4s. 3d. per ton and its export became no longer remunerative. In consequence, it was found more profitable to export whole nuts to Canada and the United States where their excellent quality ensured a ready market. A large export of nuts resulted and in 1935 the value of the coconut export was three times that of copra. At the time of writing there has been a pronounced rise in the price of copra to as much as £20 per ton and there will probably be, in consequence, a reverse swing of the pendulum in 1937. In any case, the matter is of little moment to the planter, for the the minimum of equipment is needed in the preparation of copra. Practically all the copra produced is shipped to Trinidad and Barbados from which it is reexported.

The complementary nature of the exports of coconuts and copra is brought out graphically by Figure 10.

Bananas. The last of the major export products of St. Vincent to be considered is that of bananas. Prior to 1935, although bananas had been grown to a certain extent on the island for local consumption, the export was almost negligible. In 1934 a coöperative Banana Association was created to control the

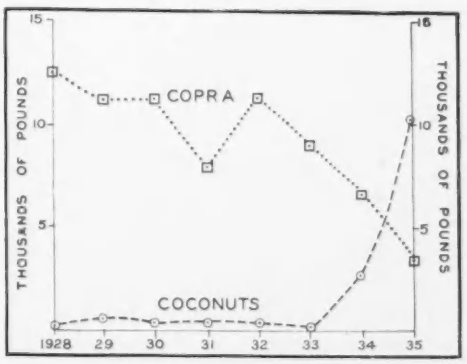

FIGURE 10.—Relative value of coconut and copra exports, 1928–35. After a severe decline in 1931 the value returned to the level of the year before, but since then it has declined steadily.

export of all Gros Michel bananas from the island. This Association agreed to supply the Canadian Banana Company with all export fruit during the five-year period 1936–40, but exports actually commenced in July, 1935. Fifty-eight cents is paid for each count bunch of 9 hands, bunches of 8 and 7 hands being reckoned as ¾ and ½ count respectively. Six hand bunches are reckoned as ¼ count and the Company is not obliged to accept them for purchase.

The confirmation of this contract caused an immediate stimulation of the banana industry in the island and the export increased from £46 in 1934 to £475 in 1935; $13,140 (£2,655) was obtained for the 1936 crop and about three times this amount is expected in 1937.

The bananas are grown for the most part in the deep valleys of the leeward

coast where they are comparatively sheltered. About 1,000 acres are now under production, but this includes some unsuitable land. It is unfortunate that the sheltered Marriaqua Valley (on the windward side of the island)—a locality well suited to banana cultivation—should be severely infected with Panama disease which is almost absent from the leeward valleys.

Complaints have recently been received from the importing company of damage to the fruit during transport to Kingstown, and the Company has actually refused to ship 7 hand bunches though obliged to pay for them by contract. Steps are being taken, however, to ensure more careful handling and instructions in this matter are being given to growers by the Department of Agriculture. It would be a severe blow to the island if such a promising industry, and one well adapted to the climatic conditions, were allowed to dwindle through a fault so easily remedied.

MINOR EXPORTS

Livestock. Of the minor industries from St. Vincent that of the raising and export of livestock has proved the most stable and profitable. It was actually one of the very few to show a definite increase during the worst years of the world depression. Cattle, goats, and sheep are all exported in considerable numbers, but are far outstripped by pigs. Almost any day one may see boatloads of grunting animals being transported to the inter-island schooners and sloops in Kingstown harbor. The export is mainly to Trinidad, though Barbados takes a few cattle and Martinique some sheep and goats. The following figures for 1935 are typical and include poultry besides a relatively small and diminishing export of draft animals.

FIGURE 11.—A banana plantation in the Middle Buccament Valley. The bananas are grown for the most part in the deep valleys of the leeward coast where they are comparatively sheltered, and where the Panama disease has not yet penetrated. About 1,000 acres are now under production, but this includes some unsuitable territory.

TABLE IV

EXPORT OF LIVESTOCK FROM ST. VINCENT, 1935

	No. in Island	*No. Exported*	*Value of Exports in £*
Pigs	6,182	2,390	3,954
Goats	2,813	2,114	758
Sheep	2,205	958	485
Cattle	6,070	22	135
Asses	2,365	45	85
Horses	357	2	55
Mules	169	2	25

The export of poultry to Trinidad is also a fairly constant and profitable one and has averaged £600 over the last six years.

Vegetables and Fruit. Other profitable export crops, almost entirely to Trinidad and Barbados, are peas and sweet potatoes, yams, plantains and tannias. Of these, sweet potatoes are the most important and are taken by Trinidad alone.

A promising tomato export industry to Canada, and later to Bermuda also, was initiated in 1929 and had grown to very considerable proportions by 1932 when diminishing purchasing power of the importing countries and overstocked markets led to serious losses. Since that date only small quantities of tomatoes have been shipped, but better prices obtained. Since the tomato export industry has made a complete recovery in Montserrat, there is hope of some improvement in St. Vincent.

The export of tomatoes and of fruit other than bananas is controlled by an active Government Fruit and Vegetable Bureau which is always on the lookout for fresh markets, while the system of coöperative marketing carried out by the Bureau secures the maximum return to the grower. Nevertheless, the export trade of fruits, the most important of which is the lime, has been so far relatively unimportant.

Cacao. The cacao industry of St. Vincent has suffered a marked decline in recent years, but this is not regarded as a serious matter, for the humidity of the island air is somewhat too low for the trees to bear really well and they are thus at a disadvantage compared with those in the hot, moist groves of Trinidad. Once more low prices have been the main cause of the decline and have not justified the cost of packing and fermentation. Cacao is, however, a crop which can be left alone for a period without serious detriment, and any considerable rise of price will probably see a certain revival of the industry.

The only other exports worthy of comment are those of peanuts, which has fallen off greatly in the period under review owing to low prices, and a useful export of spices, mainly to Grenada from which they are reëxported.

LAND UTILIZATION

The absence of a trigonometrical survey of St. Vincent, the widespread, though unsystematic, rotation of crops and, in particular, the abundance of small holdings with mixed crops render the construction of an accurate land utilization map impracticable at present. The one given by Mr. Wright still holds good, with certain modifications; for instance, it must be remembered that cotton, arrowroot, and sugar cane are grown together over most of the cultivable part of the island with the exception of the extreme north. The principal modification apart from this is the abundance of banana plantations in the Greathead, Buccament, and Richmond Valleys on the leeward coast and in the Marriaqua Valley on the windward coast.

GENERAL CONCLUSIONS

St. Vincent is an island whose prosperity is almost entirely dependent upon its export trade and the above observations may thus enable us to assess its future.

In the economic history of the island during the past eight years one thing

stands out above all others and cannot be too strongly emphasized. That is *the marked success of coöperative marketing schemes.* These have three principal effects which, in order of decreasing importance, are:

(1) They secure the maximum exploitation of available markets and control the amount of the product grown and manufactured in accordance with these.

(2) By means of grading schemes they ensure the uniformity of the products exported, which is an essential if the markets opened up are to be retained.

(3) A spirit of healthy rivalry and competition among growers and manufacturers is engendered by such grading schemes with a resulting tendency to take advantage of the expert scientific advice which is at their service in the island.

The Arrowroot Association provides an excellent example of the successful working of such schemes and to a lesser extent the Government Cotton Ginning, which is not in control of the marketing in the case of large producers. The Banana Association gives every promise of success; but the want of a grading, blending, and marketing scheme is severely felt in the declining syrup industry.

On the export of five products—arrowroot, Sea Island cotton, bananas, coconuts (or copra), and syrup—the prosperity of St. Vincent is chiefly dependent, and all but one of the five industries are in a healthy condition. The island is making a steady recovery from the economic depression and its agricultural future is bright in comparison with many of its neighbors.

The writer desires to express his extreme indebtedness to the following gentlemen for much kind assistance in the preparation of this article:

His Honour Mr. A. A. Grant, C.M.G., Administrator of St. Vincent; Mr. A. K. Briant, Agricultural Superintendent; Messrs. C. K. Robinson and C. B. Seale, Arrowroot and Sugar specialists respectively of the same Department; Mr. G. Wright, author of the previous article on the same subject; and Mr. G. G. Gianetti, Librarian of the Imperial College of Tropical Agriculture.

He carries away with him the happiest memories of hospitality in the West Indies.

Many of the facts and figures given in this article have been drawn from the following sources:

The Blue Book of St. Vincent, 1928–35.

The Annual Report on the Agricultural Department, 1928–35.

The West Indies Year Book, 1928–35.

The Reports of the Annual General Meetings of the West Indies Sea Island Cotton Association, 1932–36.

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ECONOMIC GEOGRAPHY OF PALESTINE

E. Ray Casto

PALESTINE is the most universally known of all lands. Its relation to the three great religions—Jewish, Christian, and Mohammedan—insures it a place in the minds, and in the literature, of the peoples of the world. It has been carefully studied from archaeological and historical viewpoints; but the average individual in any land, even Palestine itself, has meager information concerning the economic geography of the little country which is the ethical heart of the world.

Palestine is a bridge country lying at the crossroads of the great continents of the Eastern Hemisphere. It is a small country—so small that its size has always been a theme for amazement; it has been called the "least of all lands." But it is a land of great variety of topography. In few, if any, other countries may so many and so diverse physiographic features be observed within so brief a compass. Because it is a land of great variety of soils and of climates, it produces a remarkable diversity of products.

Physiography

Physiographically Palestine consists of three parallel strips: The Coastal Plain, the Uplands or Hill Country, and the Rift Valley. The Coastal Plain lies along the Mediterranean. It is broad in the south and narrows northward. At the Carmel Peninsula it is only two miles broad while northward from Mount Carmel it is from ten to four miles in width. This section of the Coastal Plain is connected with the Jordan Valley by the fertile plain of Esdraelon.

The Uplands or Hill Country also parallels the Mediterranean and varies in width from 40 miles in the south to 25 miles in the north. It comprises three divisions: Judaea, Samaria, and Galilee. Judaea, the southern portion, is a bleak limestone plateau. It is difficult of access and has but few fertile spots. Samaria is the central portion of the Hill Country and, while a plateau, is so broken into ridges and wide valleys as to provide much arable land. It is easy of access and has been much influenced by neighboring nations. Galilee, the northern portion, has the most varied topography of the three provinces. In addition to the limestone upland, it includes the great plain of Esdraelon and the northern portion of the Jordan Valley.

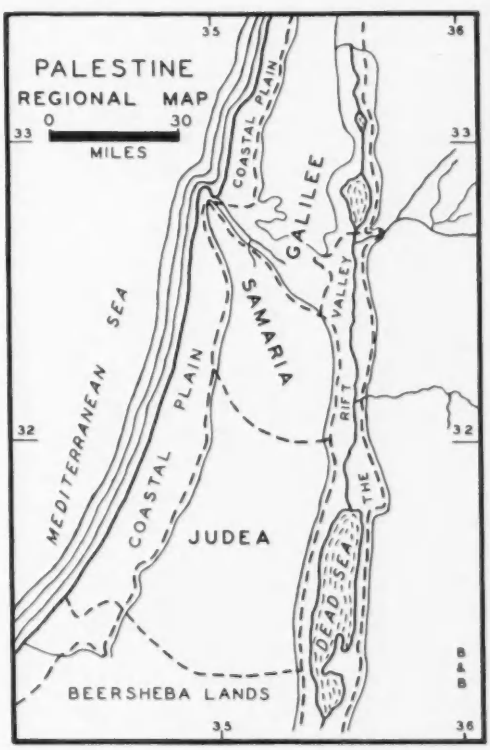

FIGURE 1.—The great southern desert, a triangular area extending to the Red Sea, is not shown on this map.

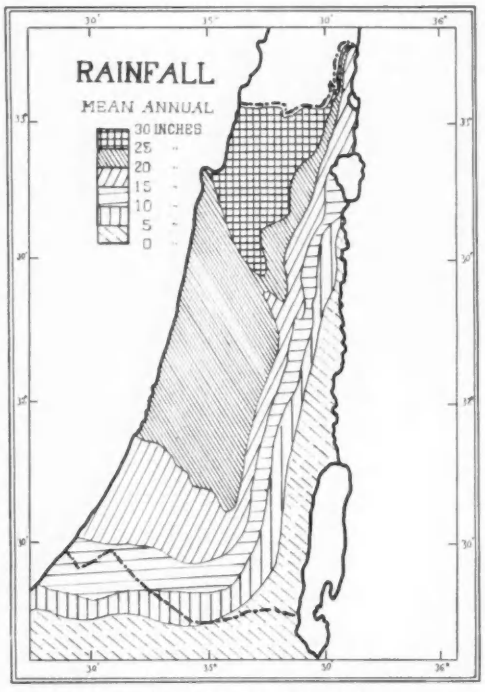

FIGURE 2.—In Palestine, except for the northern portion, the months of June, July, August, and September are (practically) rainless.

The Rift Valley is a remarkable depression 10 to 15 miles in width, with precipitous sides; the floor is level or gently sloping, and from north of the Sea of Galilee to far south of the Dead Sea its surface is far below sea-level.

CLIMATE

Palestine has the Mediterranean climate which means rain in the winter season and drought in the summer season. It is characterized by great annual range of temperature. On the Coastal Plain frost seldom occurs and snow never falls. At Jaffa the average temperature ranges from 55° F. in January to 79° F. in August.

The uplands have greater extremes of temperature than the lowlands. At Jerusalem the range is from 45° F. in January to 74° F. in July and August. During the winter months frosts are common and snow falls occasionally. The considerable daily range of temperature aids in giving the highlands of Palestine an invigorating climate. The cool sea-breezes which temper the summer heat of the Coastal Plain bring daily relief to Jerusalem.

The high atmospheric pressure of the Rift Valley makes the climate oppressive. The temperatures are high. Frost is unknown, the lowest recorded temperature at Jericho being 46° F., with a range of from 54° F. in January to 89° F. in August.

In Palestine rainfall decreases southward, Haifa has a rainfall of 27 inches, Jaffa 23 inches, and Gaza 16.5 inches. Except as influenced by altitude, rainfall decreases eastward. Jerusalem at an altitude of 2,700 feet has a rainfall of 25 inches. Eastward from that crest of the upland, rainfall decreases rapidly towards and into the Rift Valley. The eastern slopes of the plateau from Jerusalem to Jericho are desert—"The Wilderness of Judaea." Along the plain of Esdraelon the winds of the Mediterranean penetrate the Rift Valley and give some precipitation, elsewhere the valley has a nearly rainless climate due to descending winds and to intense heat.

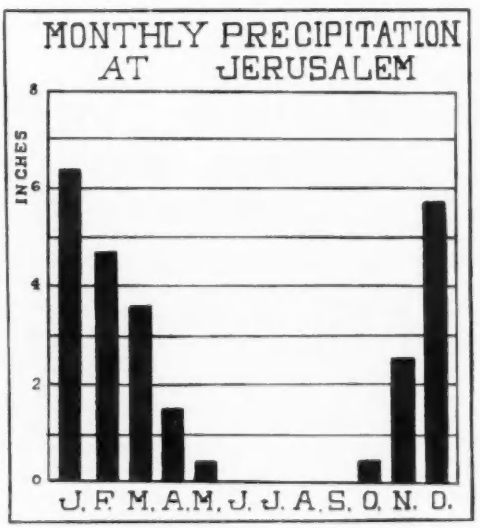

FIGURE 3.—The mean annual rainfall at Jerusalem is 25 inches.

POPULATION

The population of Palestine in 1934 amounted to 1,234,000; the density 139 per square mile; 24.3 per cent are Jews, 61 per cent are Moslems, 8 per cent are Christians, 5.5 per cent are nomads, 1 per cent Druze, and 0.2 per cent military forces. The estimated population for 1935 is 1,276,000, the 375,000 Jews constituting 29.8 per cent of the total.

In 1918 the Jewish population in Palestine was 65,000 which was 9 per cent of the total population of 722,000. The great increase in population has been due to the rapid movement into Palestine of Jews who are investing their money and their lives in the development of the New Palestine. The city of Tel Aviv, established in 1908 as a suburb of Jaffa, has today 110,000 inhabitants, of whom 99 per cent are Jews.

AGRICULTURE

Palestine has an area of 6,400,000 acres or 10,000 square miles. The geologic structure gives rise to four natural (agricultural) divisions of the land.

(1) The hill country of Galilee, Samaria, and Judaea with an area of about 2,000,000 acres, of which 1,300,000 acres are cultivable. The land hunger

FIGURE 4.—Tel Aviv. Allenby Street—a street of stores. This city is more completely Jewish in character than any other city in the world. Any language except Hebrew is a foreign language in Tel Aviv. (Courtesy of The American Colony Photo Dept.)

FIGURE 5.—Sowing a field near Ramah. A cow and a donkey are yoked to the primitive nail-plow. (Courtesy of The American Colony Photo Dept.)

of this area is shown by the fact that plots of soil so small that the plow cannot be used are planted, the mattock and the hoe being used in cultivation. Except for small areas, irrigation is impossible in the hill country and the harvests are small. But the most stony hillsides will produce the olive tree, and many of these infertile areas may yield a livelihood if planted to olives and other fruit trees.

(2) The Palestinian Plains, five in number, are: (a) The Maritime Plain, the most extensive, is that portion of the coastal plain lying between the coast and the hills to the 500-foot contour and extending from Rafa to Haifa. This plain includes about 800,000 acres, of which 600,000 acres are cultivable, and practically all of it is irrigable. (b) The Acre Plain is that portion of the coastal plain of Palestine which lies north of Haifa. This plain is narrow and has an area of about 140,000 acres, of which 95,000 acres are productive. Water for irrigation is abundant. (c) The Vale of Esdraelon has an area of 100,000 acres, almost all of which (94,000) are cultivable. Many of the villages of the Jewish colonists in this Vale show delightful signs of success. This plain is considered the most fertile region of Palestine. (d) The most northerly of the lands of the great rift of Palestine is

FIGURE 6.—Tares are pulled from among the wheat in early spring. Women and children are weeding this wheat field at Bethel. (Courtesy of The American Colony Photo Dept.)

the Huleh Plain. It lies to the north of the Lake of Tiberias and has an area of 48,000 acres. If the Huleh marsh is drained, practically the whole of the area may be cultivated. (c) The Plain of the Jordan includes the Vale of Jezreel and has an estimated area of 266,000 acres, of which 140,000 are cultivable. The greater part of the production area may be irrigated with profit, and thus produce early vegetables and all kinds of tropical fruits.

(3) The Beersheba Lands have an estimated area of 800,000 acres, of which about 400,000 may be cultivated. If artesian water should be found (as some think possible) in this area the region will have a bright agricultural future.

(4) The great southern desert has an area of 2,170,000 acres, of which no appreciable amount is cultivable.

WHEAT

Wheat is the chief crop on non-irrigated soil in Palestine, and is found on 395,360 acres or one-fourth of the land under permanent cultivation.

Palestine does not produce sufficient wheat to feed her people. An average of 1,600,000 bushels is imported annually chiefly from Syria and Trans-Jordan. Prior to the World War much Palestinian wheat was exported to Italy and France for use in the manufacture of macaroni. Recently there has been little exported, in part due to the increase in the population of Palestine, and in part due to the high import duties in Italy and France.

About 70 per cent of the cultivated area is suitable for wheat culture, the soils being of the heavy type. The soils used for wheat are generally deficient in nitrogen and available phosphoric acid. The fertility of these soils is best maintained by use of stable manure.

The average (1921–1928) production of wheat is 88,000 tons. The Jaffa district produces 12.5 per cent of the wheat of Palestine. The average yield per acre is very low, about ten bushels. The total (seed and food) per capita consumption of wheat is 6.3 bushels. This is greater than the amount (4.5 bushels) consumed per person in the United States.

In Palestine bread is the chief food, especially of the Arab, and considerable wheat is consumed in forms other than bread, e.g. roasted grains, qualiyeh, and burghul (groats). Other starch foods such as potatoes, rye, and rice occupy a minor place in the diet of the Palestinian; however, durra and barley are much used by the poorer rural population.

The cultivation of wheat in Palestine is recorded in some of the earliest pages of sacred history. Isaac sowed the land of Gerar and reaped a hundredfold. Present methods used in cultivation and harvesting do not differ much from those in use in Bible days. The principle of seed selection, now so strongly advocated by agriculturists, was early practised by the Hebrew farmers, for the injunction (Lev. 19: 19) "Thou shalt not sow thy field with mingled seed" was given to direct the Judaean sower in the way of

securing a good crop and, in Matt. 13: 24–30, the sowing of good seed is stressed.

The breach between production and consumption of wheat in Palestine can be narrowed by the adoption of a system of soil restoration, lowering of land rents, and improved methods of cultivation. The fellaheen raise 95 per cent of the wheat of Palestine under primitive methods. For these people wheat culture is the main basis of existence.

The ordinary farmer, or fellah, uses light, inexpensive, homemade agricultural implements: the essential being a light nail-plow, a sickle, a threshing board, and two sieves. These constitute almost his entire working equipment, and apparently are little different from the implements used in Biblical times. The primitive plow of the farmer of Palestine has some advantages over the modern plow. The nail-plow is light, hence requires little draught power, which is fortunate, since Palestine draught oxen are so light they are not able to draw heavy implements. Thus the fields may be worked soon after a rain, when for heavy animals and heavy implements the soil would be too wet. But the nail-plow does not penetrate the hardened soil which results from the summer drought, and it is not efficient in destroying weeds. The tourist who ridicules the nail-plow which is used by the fellah fails to recognize that no other plow could be used in the stony hill country of Palestine. This primitive plow performs all the functions for which farmers in other lands use a combination of machines: a plow, a roller, and a harrow.

The soil is plowed as soon as the autumnal rains have softened it, and by the end of October sowing of wheat begins, to be continued through November and even into December. The method

FIGURES 7 AND 8.—Primitive methods employed in agriculture make the work tiresome. In most parts of Palestine threshing is done entirely by treading the grain out beneath the feet of cattle, camels, or asses tied together. Usually three to six animals abreast are driven round and round over the spread-out grain upon the threshing floor. The winnowing of the wheat is also primitive. (Courtesy of The American Colony Photo Dept.)

of sowing is broadcast in which the seed is thrown loosely over the field (Matt. 13: 3–8). At the beginning of shooting of wheat early in the spring, the women weed the wheat fields while the men are occupied with the cultivation of the summer crops.

The fellah cuts his wheat with a hand sickle if the plants are tall, leaving a long stubble upon which cattle graze. This stubble is an important source of fodder in stock farming, but if the grain is very low it is pulled up by the roots. Men reap and bind at the same time. Women or children make heaps of the sheaves and sometimes assist with reaping and binding the grain. The sheaves are transported to the threshing floor by donkey or camel. When hauled by a donkey it is loaded on a saddle-shaped wooden frame, fitted with ropes.

The threshing-floor is a level plot of ground prepared for use by beating down the earth till a hard floor is formed. Usually several of these floors adjoin each other, for the communal threshing-floor is the plan of most villages, each fellah having a plot assigned to him on which to pile and thresh his crop. The threshing-floor must have an even, hard, stone-free surface. Often a flat rock surface is selected. The sheaves are piled upon the threshing-floor and the grain is trodden out by animals; usually oxen, but sometimes donkeys or camels, two to five abreast, are driven around in a circle. Sometimes a threshing-board is drawn over the wheat by a horse, ox, or mule. This board, made of hard wood, is bent upward in front, with holes made in the under surface into which hard stones (e.g. basalt) or jagged iron knives are fastened. The threshing-board not only separates the grain but cuts the straw and makes it a good fodder for the cattle. The root fragments of the pulled wheat and the coarser straw are much used as fuel or in the making of bricks.

In all the threshing processes the wheat is occasionally turned by a fork, and when sufficiently threshed it is tossed by the fork against the wind to separate the grain from the chaff; thus winnow-

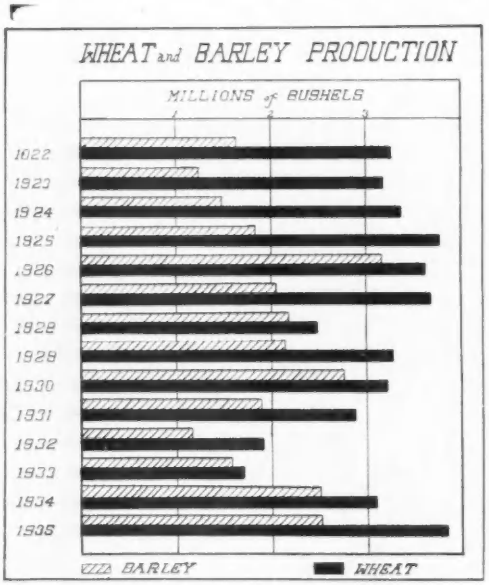

FIGURE 9.—Wheat and barley are important crops in the agricultural economy of Palestine. The low yields of 1932 and 1933 were due chiefly to drought. Wheat is the country's second most important crop while barley ranks third.

FIGURE 10.—Sesame stacked for curing. Sesame cultivation is worth while aside from its commercial value; it is a summer crop and requires careful cultivation, thus the land is in good condition for the winter cereal crop. (Courtesy of The American Colony Photo Dept.)

ing and cleaning go hand in hand with threshing. The winnowed grain contains many impurities, stones, bits of earth, weeds, pieces of straw. It is cleaned by use of sieves made of braided guts. The coarser sieve retains the larger impurities while the wheat and the weed seeds and earth sift through. The finer sieve retains the wheat while the impurities go through the sieve. The wheat thus produced is found on the market.

BARLEY AND MINOR CROPS

In 1934 the barley crop (2,538,000 bushels) was considerably greater than that of 1933 (1,558,000 bushels). Barley is used by the poor for making bread and it is the chief feed of livestock. The barley harvest is earlier than that of wheat, hence these crops do not compete for labor. Much barley is exported, especially to England, where it is much prized for malting.

Barley and wheat are grown in winter. The best summer crop for preparing the land for these winter cereals is durra. This plant is much like that of Indian corn, but it forms its grain in a head similar to that of broom-corn or sorghum. Durra is planted at the end of the spring rains. It grows and matures without rain; however, it is sometimes irrigated. The bulk of the durra crop is exported. Sesame is also grown for preparing the land for wheat and barley. The oil from the sesame crop of Palestine is extracted for local use. The sesame seed is the richest in oil of all the important oil-seeds, its oil yield being more than half its weight.

Palestine produces many leguminous crops. The chief of these are beans, lentils, and peas which are quite important locally both as food for the people and as feed for their domestic animals.

The gardens of Palestine produce a wide variety of vegetables, the more important being the cucumber, which is eaten without preparation or seasoning of any kind, and tomato, which is a valuable addition to the fruits of that hot and dry climate. The cauliflower, large and of delicious flavor, is a prized vegetable. Eggplant, okra, cabbage, and potatoes are being grown commercially. Several of the flowering plants of Palestine are used as sources of oils for the making of perfume and medicines, and as ingredients for flavoring and coloring in cooking.

GRAPE AND WINE INDUSTRY

The vine has been successfully cultivated in Palestine from the earliest times. The spies sent out by Moses returned with a great cluster of grapes

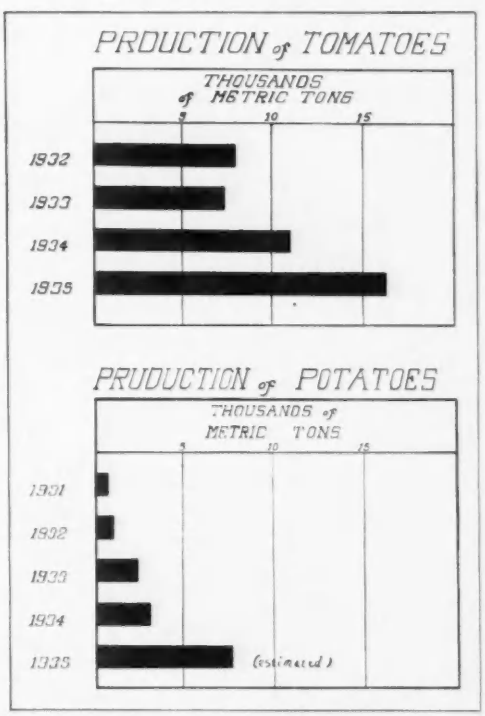

FIGURE 11.—The tomato and the potato crops of Palestine are increasingly important. The recent rapid expansion is largely the result of the increasing consumption due to the dietetic demands of the immigrant population. Importation of these products is rapidly decreasing and with the present rate of production there is no reason why Palestine should not satisfy its requirements of these crops.

Vineyard in winter
"In winter lay me down"

Vineyard in summer
"In summer raise me up"

FIGURES 12 AND 13.—The Bible makes frequent reference to the vine, the grape, and wine. Recently the Jewish colonists on the Plain of Sharon have developed an important wine industry. The vine is delicate and requires much care. (Courtesy of The American Colony Photo Dept.)

borne on a staff between two of the men. The grape was cultivated in Palestine throughout the entire period of Jewish occupation, but only for local consumption. In Palestine the growing of grapes did not become a commercial industry until the last decade of the nineteenth century, when the purely commercial wine industry was introduced by Jewish colonists on the Plain of Sharon.

The climate of Palestine is well suited to the grape, which attains perfection during the prolonged sunshine and the dewy nights of late summer. The vine does well on the hillsides unsuited for cereals.

Various systems are used in viticulture. Sometimes the vines are supported by stakes, sometimes planted at the edge of terrace-walls and trained along their tops, sometimes several vines are planted so as to support one another by being fastened together at the top, to form a kind of cone, and sometimes allowed to spread out flat on the ground, but when the grapes are developing the vine-dressers prop up the branches with sticks just high enough to keep the fruit off the ground. They follow the proverb concerning the growing of the vine, "In Winter lay me down, in Summer raise me up." In spring the soil between the vines is dug or plowed up and the plants pruned; the surface roots being cut away in order to force the development of the lower roots extending down to the underground moisture. Pruning of the vine also throws the strength into a few shoots and increases the yield of fruit. If the owner of the vineyard neglects this care his grapes deteriorate. A settled population is essential to the successful cultivation of the vine, since the plants require several years of care before bearing grapes and constant attention if they are to maintain a high degree of excellence; thus to sit under "one's own vine and fig tree" was a popular conception of peace. Several of the parables of the Master Teacher relate to vines and their culture.

The chief part of the fruit of the vineyard in ancient times was manufactured into wine. The ancient wine presses cut

in rock are still frequently seen in many portions of the land. The Biblical expression (Matt. 21: 33) about digging a wine press is quite literal, for the vats were dug in the surface of the rock. In a large shallow vat the grapes were trodden by the naked feet, and lower down the slope a smaller but deeper and narrower vat caught the juice from the crushed fruit. Near the wine press was built a watch tower in which the owner's family lived during the grape season. The tower served to guard against thieves, foxes, and the depredations of livestock.

An important product in the days when sugar was little known was dibs or grape honey. This was made by boiling the grape juice cleared by a bit of clay. It is syrupy, intensely sweet grape juice and is still made in some parts of the country.

The raisin making process is simple. The ripe grapes are dipped into a lye of wood ash and water, with a small amount of olive oil on top of it. They are

FIGURE 14.—Vineyards and olive groves near Bethlehem. The scenery about Bethlehem is inviting and restful. The terraced hills are covered with fig and olive orchards or with vineyards. (Courtesy of The American Colony Photo Dept.)

FIGURE 15.—Bethlehem maiden picking olives from branches. Some of the people are well dressed in native costumes even when at work. (Courtesy of The American Colony Photo Dept.)

drained and spread on the roof to dry in the sun. It requires two weeks to dry the grapes and no care is needed unless heavy dews demand occasional covering of the raisins.

The housekeeper of Palestine finds use for the leaves of the vine. A favorite dish is the rissole of chopped meat and rice wrapped up in them. The leaves are dried and kept for winter use.

During the time of the Mohammedan occupation little wine was produced in Palestine and the ancient wine presses were entirely neglected for it is contrary to the religion of the Mohammedan to use wine or to manufacture it. Thus the culture of the grape decreased until recent years. Today the production of grapes is increasing rapidly. In 1932, 21,553,000 pounds of table grapes were produced which was a gradual but marked increase over the 6,590,400 pounds in 1924. Wine and its by-products now rank among the leading exports from Palestine. The wine cellars of a Jewish colony on the Plain of Sharon have a storage capacity of 1,540,000 gallons—among the largest in the world. Palestine wines for sacramental use find a promising market in the United States.

OLIVES

Palestine has about 173,000 acres in bearing olive trees which yield large quantities of olives. The production varies markedly from year to year being 15,500,000 pounds in 1929–30, 3,000,000 in 1930–31, 33,900,000 in 1931–32, and 6,600,000 in 1932–33. The olive oil of Palestine usually has a high acid content and hence is of inferior quality. The lack of cleanliness in the process of extraction, the primitive nature of the machinery used, and the antiquated containers in which oil is stored are responsible for the low grade of the Palestinian product.

The olive tree is often called "the Blessed Tree" and by the fellaheen is considered sacred as the giver of food and light. The olive tree requires many years to grow to maturity for bearing. The planter of orchards may expect to eat of the fruit of the fig, pomegranate, or other fruit trees, but the olive orchard is planted for his sons. Olive trees are grown from stocks or shoots around the tree roots; the stocks taken from wild trees are reputed to have greater strength. After transplantation these shoots are grafted. In about fifteen years the trees are in bearing, but a good crop does not occur every season. The olive grower fears heavy dews during the period the trees are in flower, for the pollen is injured by moisture. The crop ripens in November. The busy picking season is known as the "olive holidays"; men, women, and children all have a part. The better of two methods is used when men and boys climb the trees and throw

the fruit down to the women and girls who spread cloths to receive it. In many villages a cruder method is employed. The trees are beaten with long sticks and the bruised fruit is collected from the dirty ground. This rough treatment is very harmful to the trees. Whatever the method of gathering the fruit the villagers make merry during the picking season, for songs are sung during the process.

The olives are collected in baskets or goat-skin bags and carried to the mill. In Biblical times the oil of the olive, like the juice of the grape, appears to have been extracted by treading (Micah 6: 15). Today the olives are placed in a stone basin where they are crushed by an upright millstone. This stone is turned by an animal, usually a camel, blindfolded so that it will not grow dizzy, harnessed to the stone by a long pole. When the olives have been reduced to marc or pulp, the oily mass is placed in bags or in flat baskets which yield the olive oil when squeezed by a rude press.

Not infrequently olive oil is extracted in a yet more primitive way. The women beat the olives with a stone pestle. They place the pulp in hot water and skim the oil from the top when it rises. This process gives "pure olive oil beaten" (Exodus 27 : 20) which is fit for offerings to be used in the lamps of the holy places. Modern methods of lighting have little altered the Palestinian use of olive oil to light churches, synagogues, mosques, and shrines.

Olive oil is held in great esteem in daily life. Babies are rubbed with oil and salt to make them strong. (It was used by the good Samaritan to heal the man on the road to Jericho and by the wise virgins for their lamps.) Some Palestinians begin the day by drinking a small portion of oil; it is used in cooking, spread on bread or bread is dipped into

FIGURES 16 AND 17.—Crude methods are still employed in gathering olives. The trees are beaten with sticks and the bruised and soiled fruit is collected from the ground. (Courtesy of The American Colony Photo Dept.)

it, burned in lamps, and applied externally in anointing.

The wood of the olive tree is excellent for fuel, but it is so largely used in making souvenirs for pilgrims and tourists that the amount used for fuel is slight. At Hebron the glass furnaces are fed with waste olive pits and pulp.

Such culture as is given the olive is primitive. The fellaheen is ignorant on the subject of pruning. In fact in most areas pruning is not done because of desire to improve the tree or crop but rather because of the necessity of obtaining firewood. The olive tree is small and evergreen. Noah was assured that the flood had vanished because the dove was able to pluck a leaf from this lone tree and bring it to the ark (Gen. 8: 11). The wood is hard, of slow growth, and has beautiful grain. The holding of large stores of olive oil is considered evidence of wealth in Palestine.

FIGURE 18.—Making olive oil. The olives are placed on a concave rock and crushed by rolling a stone back and forth over them. (Courtesy of The American Colony Photo Dept.)

In the matter of care of trees (cultivation and pruning), picking, crushing, pressing, instruction and demonstration would give good results.

It is possible to greatly extend the area under cultivation for there are large areas in the hill country which would produce a profitable olive crop. Considerable area of the hill country now given to cereals would be utilized to better advantage if planted to olives.

ORANGES

Oranges are said to be native to Palestine, but they did not attain importance as a commercial crop until the last decade of the nineteenth century. The commercial cultivation of the orange was introduced by the Arabs, but there is no doubt that the degree of perfection to which the orange industry of Palestine has been developed is due to the enterprise of Jewish colonists who have introduced scientific methods of orange culture. These immigrants promote the industry by selection of seedlings, budding in the nursery, combating of pests by scientific methods, and instruction in packing, shipping, and marketing of the fruit. Inferior fruit is used in by-product industries—orange oil, and orange juice—which are found to exert an important stabilizing influence.

The season of orange blossoms is about six weeks in duration and is highly prized by the keepers of bees. During this period hives will give two crops of orange honey, a type very popular because of its delicate flavor.

The rapid expansion of the industry since the beginning of Jewish settlement is shown by the fact that while in 1921 the total area given to citrus fruits was 8,000 acres, the Jews owning 2,000 acres, in 1934 the total acreage was 26,500, the Jews owning 13,340 acres. Large tracts of land are being planted to orange groves.

FIGURE 19.—Railroads and auto trucks are found in Palestine. Although primitive and economically defective, the chief means of transportation is the camel caravan. Even in the rapidly developing orange industry the camel plays an important rôle by carrying boxes of oranges to market. (Courtesy of The American Colony Photo Dept.)

Production of oranges increased from 2,500,000 boxes in 1928–1929 to 6,600,000 boxes in 1934–1935. At the present rate of development of new groves an annual export of 20,000,000 boxes may prove a reality. The United Kingdom is the chief market for Palestine oranges, but about 25 per cent of the boxes exported from Palestine go to continental Europe. The exports of fruit show continuous increase. The rapid evolution of the orange industry has made it the dominating factor in the economic development of Palestine. The value of oranges exported, $15,500,000 in 1935, is eight times that of grapefruit, $1,900,000 in 1935, the next most valuable export.

GRAPEFRUIT

Usually one-tenth of the area of an orange grove is planted to grapefruit which has a satisfactory and an expanding market. In Palestine grapefruit of very excellent quality thrives in soils which are too heavy for the successful growth of the orange. In the Jordan Valley there is considerable area suitable for grapefruit which will probably not be so used, since the grapefruit is a luxury fruit requiring preparation and sugar before it can be eaten, while the Jaffa orange is easily prepared for eating. The production of grapefruit has increased rapidly. In 1929–1930, 20,000 boxes were produced; in 1934–1935, 400,000 boxes.

BANANAS

The banana, one of the world's most important foods, can be grown in the whole Jordan Valley provided the soil is fertile. The banana of Palestine is not attractive in appearance but it is of excellent quality. Occasionally banana growers have difficulty in marketing their fruit since the Palestine banana is restricted to local markets and develop-

FIGURE 20.—Near Joppa may be found many examples of two-storied fruit culture. The date palm and the orange tree are good neighbors on the Plain of Sharon; example of two-storied fruit culture. (Courtesy of The American Colony Photo Dept.)

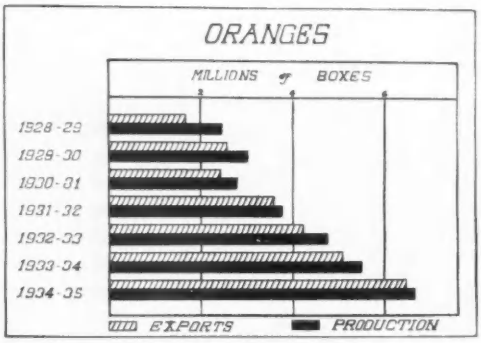

FIGURE 21.—The world consumption of oranges has markedly increased in recent years. The rapid expansion of the orange industry in Palestine during the present decade has enabled that little country to secure and hold an important place in the world markets for this fruit and has made the orange the dominating factor in the economic life of the country.

ing markets of eastern Europe. In other parts of the world Canary or West Indian bananas crowd Palestine bananas from competition. The forecast for this excellent fruit appears to limit it as an industry of moderate dimensions in Palestine.

WATERMELONS

The watermelon is extensively grown in Palestine. The fruit is of excellent quality. There is a large trade with Egypt (49,000 tons in 1929) and a notable trade with Syria (7,000 tons in 1928).

ALMONDS

The almond tree flourishes in Palestine, about 7,000 acres being given to this easily cultivated tree since it thrives on land unsuitable for other crops. It is highly productive, yielding a return six times that of wheat or barley. Almond culture improves poor soil. The acreage in almonds has decreased as a result of the increasing popularity of the orange, large groves of almonds having been uprooted to give room for orange groves. Large quantities (900 tons in 1925) are exported to Egypt and Damascus, the chief markets.

CAROB

The drought-resistant carob tree occupies considerable rocky and dry land in Palestine. It is an evergreen tree with beautiful dark glossy foliage. The flowers appear in the autumn and the young fruit matures on the tree during the following summer. The long pods of the carob were eaten by the prodigal son. They serve today as food for the poor, but they are used chiefly as feed for animals.

FIGS

The fig tree is cultivated all over Palestine. At present it occupies a place as

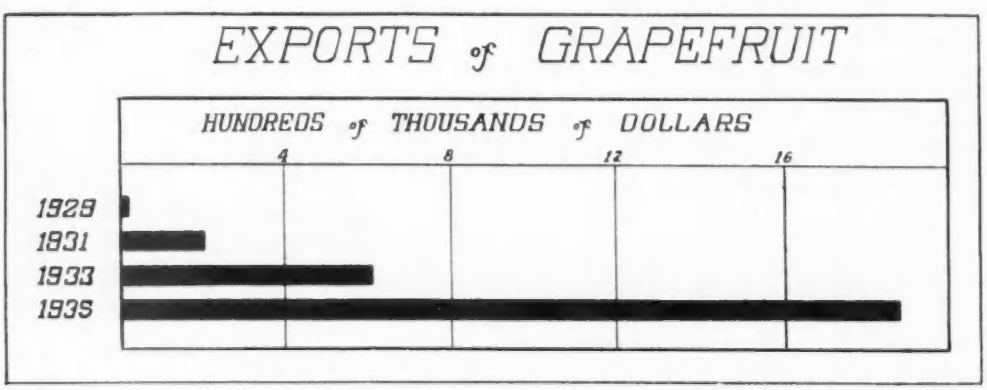

FIGURE 22.—Excellent grapefruit is grown in Palestine and it has become of considerable importance in commerce. Since 1933 it has held second place in the value of exports.

important as in Bible times. The foliage of the tree is thick and it is prized for its cool shade. The fruit is eaten fresh or dried and is frequently pressed into a lump or fig-cake.

POMEGRANATES

The pomegranate is also cultivated all over the country, especially where irrigation is practicable. It is a shrub-like tree with a richly-colored fruit. This fruit is a popular food and the bark of the tree provides a valued astringent drug. The pomegranate was used as a design for the sacred garments of priests and for decoration in architecture.

DATES

In the time of Jesus the date palm was abundant in Palestine, and Jericho was called "the city of palm-trees." The tree is sacred to many of the peoples of the land. Fruit, seeds, leaves, and bark are valuable and the attention given this crop is encouragingly increasing.

TOBACCO

Prior to 1921, due to the heavy taxation and the stringent control exercised by company monopolies, the farmer of Palestine could not grow tobacco with profit. Immediately upon the repeal of this monopoly in 1921 the growing of tobacco received such marked attention that the crop soon became quite important. Both soil and climate of Palestine are favorable for production of cigarette tobacco of superior excellence. In 1930, an average year, 920,000 pounds of tobacco were produced in Palestine.

Several small factories for manufacture of cigarettes are operating in Palestine. Few, if any, industries have met with such definite promise of success. The work is mainly done by hand at present. A tobacco factory at Haifa leads the factories of Palestine in amount of labor employed. This factory employs 500 laborers, almost all being Arabs. Since the war seven cardboard box making plants have been established in Palestine, having an interesting relation to the decrease in import of cigarette and tobacco boxes in recent years.

COTTON

In various parts of Palestine cotton is grown on a small scale. Both Indian and Egyptian varieties are being tested on experimental plots. Experts are optimistic concerning the possibilities for cotton growing.

LIVESTOCK

The importance of the livestock industry of Palestine is in large part due to the large amount of land which is unfit for agriculture. Palestine has always had

FIGURE 23.—The warm climate of the Jordan Valley is highly favorable for the banana. The irrigated plains about Jericho produce a good quality of this fruit. Recently many groves have been planted at Jericho. Some plantations are found on the Coastal Plain. (Courtesy of The American Colony Photo Dept.)

scant natural grazing for cattle and horses, and the number of these types of livestock is a low figure as compared with sheep and goats which can find enough pasture of a poor kind. In 1932 the livestock included 14,000 horses, 74,000 asses, 6,000 mules, 160,000 cattle, 248,000 sheep, 381,000 goats, 6,000 swine, 7,000 buffaloes, 32,000 camels, and 1,110,000 fowls. The raising of livestock is chiefly nomadic. As many nomadic owners of livestock shift their animals with the seasonal migration of grazing, an accurate animal census is impossible. The majority of the cattle of Palestine are draft animals, the sheep are the broad-tailed, fat-tailed sort, and the goats are of milch strains.

FIGURE 24.—The sycamore of Palestine is a kind of fig-tree. The fruit grows in clusters on the trunk and main branches. The fruit is edible (Amos 7:14). The tree makes a good shade and is planted along the roads (Luke 19:4). (Courtesy of The American Colony Photo Dept.)

The average yield of wool per sheep is 6.5 pounds. The sheep are sheared in May and June. Much wool enters Palestine from beyond the frontier, being brought in by Bedouins from the desert. Local industries use considerable of the wool, but some is exported. The local tanning industry uses the majority of the hides and skins, but some are exported.

Dairy farming is having a truly remarkable growth in Palestine. Apparently the development of this industry is the road to a sound scheme for the colonization of Palestine. Diversified farming, based mainly on dairying, produces the farmers' requirements of milk, meat, eggs, etc., for the home and also an actual money return. But monoculture, i.e. the two field cropping system, wheat and durra, yields nothing but a hardwon living. The manure made available by dairy farming has immediate effect on the soil and on the quality and quantity of crops produced.

The quality of animals bred locally is low and much improvement is being made through importation of purebred dairy stock. However, existing breeds are fair triple-purpose cattle, being of value for milk, beef, and as draught animals. They are resistant to disease and can be kept entirely on natural pasture. The orange growers provide a good market for all available stable manure provided by the developing dairy industry.

Palestine's most rapid increase in livestock has been in cattle which are essential to the improvement of agriculture in all of its aspects.

The milk of the goat is used for drinking, and for the making of butter, cheese, and leben or curdled milk. Thus the goat which is the most abundant of all livestock of Palestine plays an important part in the local dairy industry.

The camel so often mentioned in Scripture is found in increasing numbers (1922, 10,000; 1932, 32,300) in modern Palestine. He is indeed the "ship of the desert" for he is the chief means of transport over the sandy wastes, and is the most valued beast of the nomads. Camel milk, especially in a sour or thickened state, is much used for food, and the flesh is eaten by the Arabs (Lev. 11:4). The hair is shed yearly. The coarsest of all Palestinian textiles is made from

the black felt of long coarse camel's hair which forms the covers of the nomad tent, and the finest is the delicate fabric made from the soft down growing close to the camel's skin.

HONEY PRODUCTION

Palestine once flowed with honey as well as with milk. A decrease in the production of honey has been due chiefly to the neglect of bee culture and to the inferior hives employed, for there is no lack of food for bees. Palestine is well adapted to bee culture and a revival of honey production along commercial lines is now in progress. The honey-making season is short, a fact which is an obstacle to the commercial development of the industry. The plants of most importance for bees are orange blossoms in April, sage, lavender, and mint in May, acacia and cactus in June, and wild thyme in July. In order that the bees may have ready access to these honey-producing plants they are kept in movable hives and carried about from coast to hills. The annual production is more than 50,000 pounds with a marked yearly increase.

SILK

A small-scale silk industry was terminated by the World War. The Zionists are conducting experiments with a view to the reëstablishment of this industry. It has been found that the mulberry may be replaced by the castor-oil plant upon which the silk worm may profitably feed.

FORESTS

The occasional magnificent tree found in Palestine indicates that the land was once forested, but today it has no real forests. Locally there is a dearth of timber for any use. The widely distributed olive trees provide wood used by furniture and curio makers, but forest products have no important part in the economic resources of the country. The majority of the trees mentioned in the Bible are found today, but sparsely scattered. Until recently there was no conservation of forests in Palestine. In the past decade several active afforestation projects show a most hopeful outlook for the future forests of Palestine. Governmental and private agencies are giving energetic attention to the reforesting of the country. Several forest nurseries are being operated, and trained foresters are pruning and thinning the thickets of scrub. In a few decades Palestine may again have a fair growth of trees.

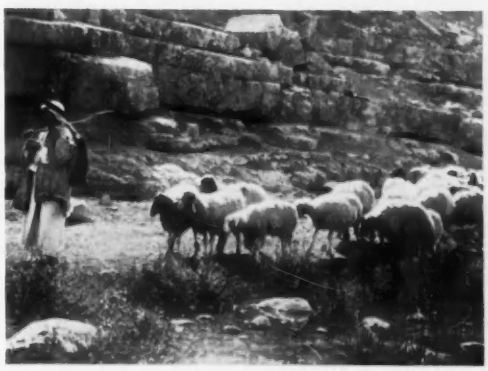

FIGURE 25.—Ain Farah, scene of the Twenty-third Psalm. The shepherd wears the Bedouin head-dress as a protection from the sun. He spends his life with his sheep and is always found at the head of his flock. His sheep know his voice. The chief uses of sheep in Palestine are for wool and milk. (Courtesy of The American Colony Photo Dept.)

FISHERIES

All of the perennial streams of Palestine have enormous numbers of fish. The Lake of Galilee has been famous for them throughout its entire history. During New Testament times fish-curing was an important industry about this lake. Today Tiberias has the only local market for the fish of Galilee, where many from twelve to eighteen inches in length are seen. Barrels of fish caught by Arab fishermen are being sent daily from Lake Huleh and the Sea of Galilee to Tel Aviv and Haifa. Considerable traffic is carried on in salt-water fish de-

spite the ill-adapted coast for the development of fisheries. During the rule of the Turks the fishing industry was effectively discouraged because it was made to support a 20 per cent sales tax. Since the removal of the tax, the industry has recovered slowly. The men have apparently lost their knack or inclination as fishermen, and Palestine imports about $300,000 worth of fish annually. Both Galilee and the Mediterranean seas offer possibilities for industrial development.

MINERAL RESOURCES

The scripture contains several references to mining and to metals, but today metallic minerals of economic value are unknown in Palestine. The mineral wealth of the land has not been carefully explored, but there is no evidence that a thorough exploration would reveal metallic treasures.

FIGURE 26.—A primitive churn of Palestine. It consists of a goat's skin supported with ropes on a tripod of sticks. This churn, half filled with milk and inflated with air, is pushed to and fro until the butter forms. (Courtesy of The American Colony Photo Dept.)

The most universal mineral resource of Palestine is building stone, chiefly limestone and basalt. Throughout Palestine stone is the chief building material; however, little is exported. An important by-product of stone is lime which enters into local commerce.

Bitumen and oil shale are found in the Dead Sea area. This bitumen has been known for a long time and is probably responsible for one of its names, the Asphalt lake. The amount of bitumen available annually is about 100 tons.

The phosphate deposits of Palestine have a wide distribution; however, more accurate surveys are necessary to determine their commercial value. Gypsum deposits are widespread, but few have been proved of commercial importance. In the Dead Sea basin large nodules of sulphur are found; although the Bedouins collect it for medicinal use, it is not sufficiently profitable to enter into trade. At the southwest of the Dead Sea is Jebel Usdum, a mountain of salt much of which is 98 to 99 per cent pure salt. This salt is locally of commercial importance, being used for domestic purposes and in certain manufactures. The slow development of this fine deposit is due to the isolation of Jebel Usdum, dearth of food and water and cost of transport.

The most important source of minerals in Palestine is the brine of the Dead Sea. This remarkable lake, occupying the deepest portion of the great rift valley, is the atrophied residue of a vast body of water that once occupied this depression even beyond the Sea of Galilee. The waters are impregnated with 26 per cent of mineral salts. The richness of these waters gives Palestine an average of mineral wealth. The work of extracting minerals from the Dead Sea began in the last half decade, and potash and bromine factories are successfully operating. The occurrence of potash and bromine in this lake give it

resources without parallel elsewhere on the earth. The clay flats surrounding the Dead Sea are used for making evaporation pans, and potash is produced by solar evaporation.

The many valuable mineral salts of the Dead Sea if developed will be the basis for a large chemical industry. The exploitation of mineral salts of the Dead Sea will have a highly beneficial effect on the agricultural development of Palestine.

FIGURE 27.—For many centuries Palestine has been deforested. The government operates several forest nurseries. Waste lands are being planted with pines, eucalyptus, acacia, poplar, and other trees. In a few decades Palestine may have a fair supply of young forests. (Courtesy of The American Colony Photo Dept.)

HYDROELECTRIC DEVELOPMENT

The economic rehabilitation of Palestine has been greatly furthered by hydroelectric development. The potential water power of the country is abundant, but the utilization of the tremendous power of the Jordan, the Auja, and other streams requires large capital, and the lack of it is the chief flaw in an otherwise practicable plan for hydroelectric development in Palestine. Several projects, e.g. Auja River, Waters of Merom, Jordan River, and Galilee projects have been planned and considerable development of power has been made. The Jordan River is rich in potential power. In the space of six miles this river falls from the level of the Mediterranean at Lake Huleh to nearly seven hundred feet below sea-level at the Sea of Galilee. The use of electricity for lighting and for power has increased rapidly, a seventeenfold increase in the seven years 1924–1931. Industry uses 43 per cent and agriculture 33 per cent of the total consumption of electricity. Transmission lines increased from ten miles in 1924 to 307 miles in 1931. The number of consumers of electricity increased by about 13 per cent annually and the number of kilowatt hours consumed increased by 57.7 per cent between 1930 and 1931. The cost of electricity in Palestine was 50 mills per kilowatt hour in 1930 and 30 mills in 1932, a decline of 40 per cent.

In 1927 construction was begun on a hydroelectric project near the confluence of the Yarmuk River with the Jordan. In 1932 a generating station was completed at this point competent to generate 60,000,000 kilowatt hours annually. The final continuous capacity will be 34,000 horsepower. Eventually several other power houses will be constructed at intervals along the Jordan.

The Jordan River flows 65 miles from the Sea of Galilee to the Dead Sea. The fall for the entire distance is given as 610 feet, but near the Sea of Galilee its gradient is about 40 feet per mile.

INDUSTRY

Pre-war Palestine gave little attention to the manufacturing industry. The simple needs of the inhabitants were supplied by local craftsmen, who used the crude methods employed for centuries. The requirements of more advanced groups—for manufactured articles—were met by importations. The traditional industries of Palestine were the weaving of cloths, headgear, and mats; textile dyeing and needlework; tanning; oil, soap, wine, pottery, and glass making; masonry and milling. Such primitive industries were inadequate to meet the demands of the rapid influx of post-

war immigrants who gave a marked impetus to organization and development of various industrial enterprises on a large scale. Before the war 1,236 of the present 3,505 operating industrial establishments were in existence. These had a total capital of $5,000,000. A recent industrial census gives the number of post-war manufacturing establishments as 2,269, or an increase of 183 per cent, and a capital of $12,500,000, or 250 per cent increase. This remarkably

FIGURE 28.—The Sea of Galilee with its fleets of fishing boats was the geographical background of the Gospels. (Courtesy of The American Colony Photo Dept.)

rapid increase has been chiefly due to the rapid influx of Jewish immigrants. These immigrants included manufacturing experts, skilled workers, and owners of capital who, recognizing the primitive status of Palestinian industry, set themselves to the task of supplying local and foreign markets with all possible products, thus developing a means for a rapidly increasing Palestinian population to sustain itself and contribute towards the development of a modern Palestine.

The industries of the past operated on a small scale, and a most remarkable feature of the development is swift increase of small industries and very slow (almost stationary position) increase of large industries. The prevalence of the small industry in Palestine is shown from the table of statistics which lists 400 factories with a total of 700 workers, or an average of less than two persons per enterprise. Although the purely Jewish industries are the progressive ones, the average Jewish establishment is very small indeed.

A census of Jewish industry in March 1930 showed the average number of workers per enterprise as 4.1 who are paid on the average about $250 per year. The raw materials used in these plants average $1,950 per year. The average invested capital per establishment is about $2,200 per year, and the finished articles average $3,600 per enterprise annually.

LEATHER

The leather industry has excellent opportunities in Palestine. Materials essential for this industry are available both in Palestine and in the surrounding countries. In general a poor quality of leather is produced because of inferior quality of hides and inefficient tanning. Corporations and individuals are giving highly interested attention to the tanning industry, and a marked increase and improvement has already been made. This industry is widespread in Palestine. Using elementary methods practically every village produces inferior or, at best, ordinary grades of leather. The skins of sheep are tanned with the wool on and serve as raincoats and as winter cloaks. The chief use of goatskins is for water bags, many being exported to Egypt. The goatskin water bag is tanned in the shape of the animal. Recently a group of Polish Jews with a technical knowledge of the tanning industry established a fancy leather industry in Tel Aviv with immediate success. The chief products are leather hand bags

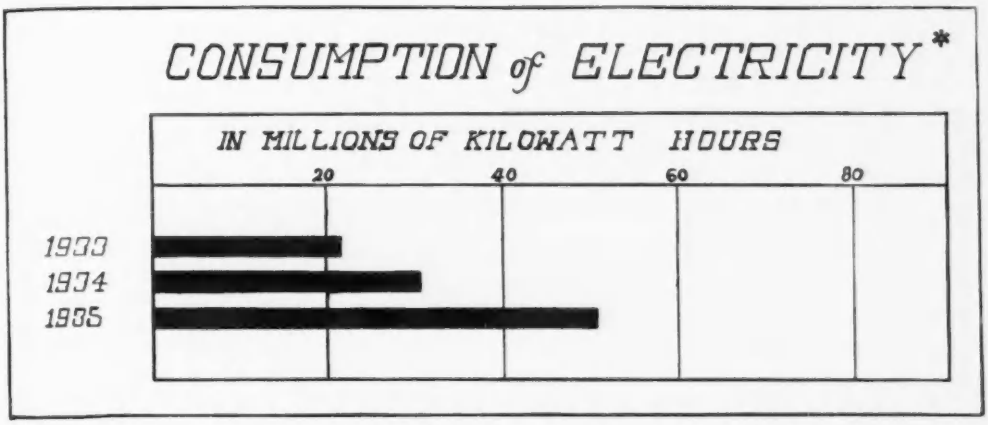

FIGURE 29.—The use of electricity both for lighting and for power is increasing rapidly. In 1924, 500,000 kilowatt hours were consumed in Palestine; in 1930, 5,500,000. In 1935 the land, exclusive of Jerusalem and its environs, used 50,400,000.

which find a ready market in Egypt and elsewhere.

SOAP

The most important of manufacturing industries which had pre-war existence is soap. Palestine had fifty or more factories manufacturing soap and thirty of these are in Nablus (Shechem), where several types of soap—laundry, toilet, Arabic, Castile—are made exclusively from locally produced vegetable oils. The "Shemen" soap factory at Nablus has its machines driven by electric motors and its production is controlled by its modern chemical laboratory, but elsewhere equipment and methods are not up-to-date. A large kettle in a soap factory holds a mixture of 16,411 gallons of olive oil and 1¼ tons of caustic soda which is cooked and stirred for seven days. It is then poured out, allowed to cool, and cut into blocks.

Soap is by far the most important industrial export from Palestine. About one-half the production of the 9,000 metric tons is exported. The chief customer is Egypt, whose Moslem population prizes the pure olive-oil soap from Nablus. In general the Palestinian soaps do not meet with the favor of Europeans and Americans; however, the present output of soap factories in Palestine could be greatly increased at a ready market.

FLOUR

Flour milling is an innate Palestinian industry. In Biblical times every family ground its own grain. The domestic hand mill consisted of two circular stones placed horizontally one upon another and, the upper being made to revolve upon the lower, reduced to flour the grain which was introduced through a hole in the rider or upper millstone. Grinding was done by the women. Today one or more flour mills may be found in every village of Palestine. The mill in most general use consists, as did the mill of Biblical times, of two circular stones. Sometimes man power is used, but where possible the stones are turned by water power. These primary mills do not separate the bran from the ground wheat. Some mills in Jerusalem, Joppa, and Haifa have been equipped with simple machinery; a very few of these produce the better grades of white flour. Haifa has the largest of the flour mills of Palestine with an annual product valued at between $450,000 and $700,000. Some of the flour is exported to Syria, but in general this firm caters to

the home market. It also operates a plant for production of "matzot," the unleavened Passover cakes, with annual output of from 300 to 450 tons, one-half of which is exported. These factories, founded by Rothschild, employ over 100 men and women, all Jews.

The wheat of Palestine is of excellent quality, but the yield is so variable as to greatly handicap flour milling. All wheats of Palestine are of the macaroni variety, and produce a "thick flour" yellowish in color. Palestinian flour mills work largely for hire as they are not able to compete with flour imported from America and Australia.

FIGURE 30.—A general view of Hebron showing in the foreground a tannery that does not use vats. The goat skins which are being tanned for city water-carriers are stuffed with oak bark and water and placed in a yard to tan. (Courtesy of The American Colony Photo Dept.)

MOTHER-OF-PEARL

An interesting and almost entirely home industry is centered in Bethlehem. It is the use of mother-of-pearl in the making of rosaries, carvings, and miscellaneous souvenirs, an industry which supports the greater part of the population in the Bethlehem area. Because much of the product leaves Palestine in the hands of tourists, accurate figures as to the value of exports are not obtainable, but the estimated annual value of the product is modestly placed at $225,000. The mother-of-pearl work is all done by hand. A few tools of a simple kind are used. Wages of workers range from 45 to 75 cents per day. Related to carving of ornaments from mother-of-pearl is the use of the material in the button-making industry. This industry originated as a charity enterprise for Jewish poor but recently, with employment of much hand labor and simple machines, it has been successfully attempted commercially.

LACE AND EMBROIDERY

Another home industry, especially in the Nazareth and Bethlehem districts, is the making of lace and embroidery. Some rough textiles of both cotton and wool are woven by hand in the homes and have their chief sale in the local markets. There are 40 textile factories in Palestine. Of these only 12 employ more than ten persons each. Hosiery making has made remarkable progress in Palestine. The exports increased from a value of $2,000 in 1925 to $95,000 in 1929.

ARTIFICIAL TEETH

A factory for making artificial teeth was opened in 1926. This unusual industry has had a rapid development, annual exports being valued at about $150,000.

GLASS

Hebron is the seat of an ancient glass industry. The glassware is blown and is of a fragile quality. It is made into

plain and roughly shaped utensils and ornaments. The furnace is fed with waste from the olive presses. The industry has no promise of commercial importance except as related to tourist trade.

BUILDING

All the early inhabitants of Palestine were tent-dwellers, and today the Bedouins live in rudely constructed tents of long strips of black hair-cloth suspended on rude stakes about six feet in height. The tent cloth is coarse in texture but is impervious to rain and makes a fine shade. It is woven by hand from the hair of the black goats.

An important industry in Palestine is building. The houses of Palestine both inside and out are in strong contrast with those of America. Few houses of wood are found in Palestine and these are made of timber transported from Europe or America. Houses of burnt brick are seldom found because fuel is too scarce and costly to warrant the burning. Chimneys are not seen and fireplaces are not found. In Palestine the term "family fireside" belongs to an unknown tongue.

The most used building material is stone. In the rocky highland section stone is used almost exclusively and all over the land it is used in the better class of houses—even roofs and stair-steps are built of stone. Wood is used in houses where indispensable, as in doors and windows. The mortar in general use is of little better quality than ordinary mud, builders priding themselves on the use of as little lime as possible. The plastering is durable and the lime beautifully white. The better houses are built of hewed stone, but the ordinary house is made of rough stones placed in a great amount of mortar.

Sun-dried bricks are masses of mud mixed with short straw from the threshing floors, pressed by hand into wooden molds and then left to dry in the sun. Women work up a stiff mud with crude hoes and their naked feet. The mold holds two bricks at a time and when filled is lifted, leaving the bricks on the ground. The bricks are turned occasionally while drying. The straw serves to retain the shape while drying and delays weathering. Tiles are sometimes used for roofing houses. The scarcity of fuel for baking the tile and of timber for supporting them on the roof prevents a wider use. Much stone is carried from the quarries on camels or on asses.

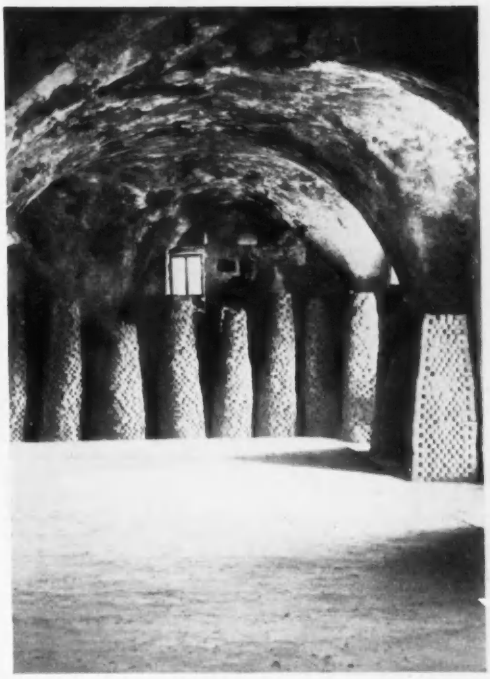

FIGURE 31.—Nablus is ancient Shechem. Soap-making is the chief industry. The town has 30 factories which make a pure olive-oil soap. Pillars of drying soap are shown in this picture. Stone floors serve as pouring tables on which the soap is hardened and cut. (Courtesy of The American Colony Photo Dept.)

A census of building and related industries (excluding timber) taken in 1928 showed 198 establishments with capital of $2,594,000, of which one cement factory accounts for $1,500,000, and a sand-lime brick factory for $375,-

000. Building in Palestine not including government public works and building in the colonies from 1924–1931 absorbed $57,000,000. Between 1925 and 1928 building activities declined, and increased following 1928, but, regardless of local constructive work, exports of cement have rapidly increased while imports have steadily declined. The excellence of the local cement is shown by its exclusive use by the British government in the construction of the fine $6,250,000 harbor at Haifa. The "Nesher" cement factory at Haifa employs 390 wage-earners and exports cement to Syria and Egypt.

TRANSPORTATION

Travellers in the Palestine of Biblical times usually made their journeys on foot and, in order to avoid the heat of the day, they travelled in the cool of

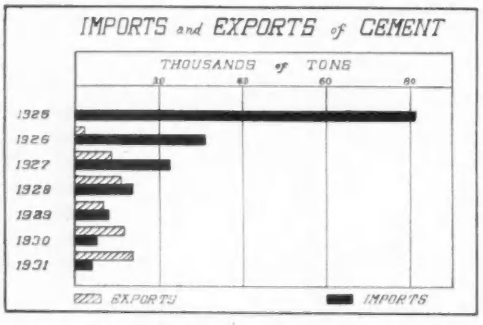

FIGURE 32.—Palestine factories are producing first-class cement. Since the World War the building industry has required large quantities of cement. However, in 1930 exports surpassed imports.

the morning, evening, or night. But the merchantmen who carried goods from, to, or through Palestine relied, and in large part still rely, on the camel, the ship of the desert. The Palestine of today has 32,000 camels and 74,000 asses chiefly employed in local transportation. Palestine has an extensive network of caravan trails which are used by pack trains of camels and donkeys in carrying both import and export goods.

In 1930 the railroads of Palestine had 656 miles of road in operation. Most of the important trade centers of Palestine have railroad connections. The railroad has an important competitor in motor transport. The rapid improvement in the road system of Palestine has encouraged an increasing use

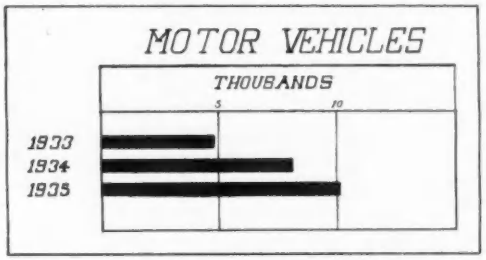

FIGURE 33.—The growth of motor vehicle traffic in Palestine is shown by the above graph of motor vehicles registered with the Palestine Government during 1933, 1934, and 1935.

of motor transport for passengers and freight. Today there are approximately 1,500 miles of fair motor roads.

The Jordan River is swift and a shallow stream and is not commercially navigable, but its broadened expanses—the Dead Sea and the Sea of Galilee—provide for limited navigation. Plans have been made for a regular transport of the wheat of Moab across the Dead Sea into Palestine. Most sea-borne commerce is discharged and loaded into lighters in the open roadsteads at the two ports of Haifa and Jaffa. At times the sea is too rough to permit the safe transport of passengers or cargo to and from shore. Harbor improvements are being made, especially at Haifa, which will in large measure overcome the obstacles to the country's sea-borne commerce. Palestine lies on the official air route from Cairo to Bagdad.

FOREIGN TRADE

The principal articles of export are of agricultural and horticultural origin. Oranges, barley, wine, durra, lentils, apricots, watermelons, soap, olive oil, and

cement are exported whereas imports are chiefly of flour, sugar, iron and steel manufactures, oils, medicines, and machinery. These products find their way to or from foreign markets chiefly by way of the ports of Jaffa and Haifa; Acre and Gaza care for a small share of the trade.

The greater part of the watermelon crop is exported by railway to Egypt. Trade routes into Syria and Trans-Jordan have rich possibilities in the development of the future international commercial importance of Palestine.

The foreign trade of Palestine shows an adverse balance, the value of exports in 1934 being $20,100,000, while that of imports was $75,300,000. United Kingdom is the chief export market for Palestine, with Germany second, and Syria third. The chief countries of origin of imports in order named are United Kingdom, Germany, and United States.

CONCLUSION

The economic situation of Palestine is problematic. The diverse and discordant racial and religious types are in large part an explanation. The rapid influx of Jews is viewed with alarm by the Arabs. The return of large numbers of well-trained Jewish people to their homeland has resulted in marked advances in agriculture and industry. The economic life of the country is being revolutionized by and for the Jews. This does not achieve the full possibilities of economic advance for the welfare, and coöperation of the Arab farmer and industrial worker must be seriously considered and desired if the economic stability of Palestine is to be secured. The New Palestine should be so developed as to improve the lot of both Arab and Jew. Jewish energy and capital have helped Palestine and the Arab, but the Arabs resent the presence of the increasing numbers of Jews and they are bitter over the British rule. Conflicts are frequent. There is dire need of a campaign for education among the less favored groups. This is the only means

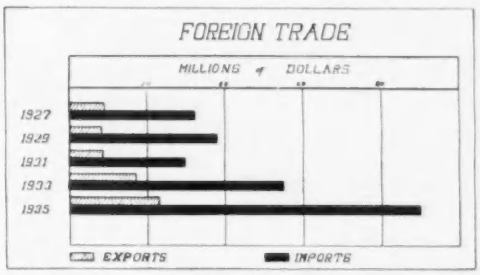

FIGURE 34.—There is a serious balance of trade against Palestine. The large sums of money expended by tourists and the amounts received by the religious and charitable institutions somewhat equalizes the great balance of trade.

of convincing the Arabs that Jewish industry in Palestine is being developed with considerable advantage to the Arab population and without any economic hurt to them.

Of the land of Palestine, 236,000 acres, or about 6.6 per cent, are in Jewish ownership. Though comprising almost 25 per cent of the population, the Jews own less than 7 per cent of the area of the land. Palestine is the focus of Jewish life and by many millions of Jews is considered the land of hope. Since the Hitler régime it has given refuge to a large number of Jews and has saved their children from an environment of hatred and humiliation.

Modern Palestine certainly must be largely agricultural, but the geographical position of the land makes it a distributing center among the continents of Europe, Asia, and Africa. It has been called a country with a past. It may just as truly be called a country with a future.

COMPARISON OF AMERICAN AND AUSTRALIAN DESERTS

Griffith Taylor

THE writer spent some twenty years in Australia engaged in geographical research, in which the chief problem was the utilization of the large arid areas in the southern continent. Every student of settlement in Australia realizes the wisdom of using the experience of the United States to help settlers in the younger land, but many make the natural mistake of assuming that practices which succeed in the American arid environment will work under Australian conditions. This paper will, I hope, help to explain certain important respects in which the two arid regions differ. It is based in part on a traverse by car through the southern deserts of the United States in the early summer of 1933.

In forecasting the future of settlement in Australia, comparison is often made with settlement in the United States. The areas of the two lands are approximately the same, but unfortunately in no other particular is resemblance close. In Figure 1 the two are placed in their appropriate latitudes with the drier lands to the west in both cases. Broadly speaking, only the southern third of the United States is allied geographically to Australia, and its homologue is the southern third of Australia. But even these lands are not homoclimes (regions of similar climate), except perhaps around Sydney and Wilmington, N. C. The salient feature in the southern United States is the great area of the Gulf of Mexico running far into the land. In Australia there is an arid lowland in the same latitude, to the great disadvantage of lands still farther to the west. It is often stated that Australia's arid interior will advance by irrigation as the western region of the United States has done. Apart from the great topographic differences, the irrigation regions in the United States are in very much higher latitudes—where evaporation is relatively low and where, moreover, rainfall in most cases is over ten inches. Arid Mexico is perhaps a fair homoclime for the arid region (about 1,200 feet high) to the southeast of Broome.

Speaking generally, the United States has about five times as much temperate land with a rainfall over 20 inches as has Australia and about one-fifth as much arid country (under ten inches). These proportions largely determine the relative economic status of the two countries. A much closer homoclime for inland Australia is found in the only other large area of comparatively low trade-wind desert surrounded by an unbroken coast line—northern Africa (Figure 1). The belts of Mediterranean flora, scrub, desert, and savanna agree quite closely with the similar belts in Australia. Of course the east coast of Australia has no homoclime in the Sahara. It is in the southern coastlands of China that we find an area with an environment much like that of eastern Australia.

It is, of course, the general arrangement of atmospheric circulation which produces deserts along the Tropics of Cancer and Capricorn. Here the dry anticyclones make their average drift to the east, and on their equatorial margins the steady Trade Winds blow from the east. We may briefly consider why Australia has so much broader a desert than has the United States. It is largely a function of the width of the continent near the Tropic, but the problem is com-

plicated by the topography. North Africa is 3,500 miles wide, and on its eastern margin adjoins the Asiatic land mass (Figure 1). Hence no moist Trade Winds from the sea reach the Sahara, and in these latitudes Africa is desert from coast to coast. Unfortunately, Australia is the second widest continent in these latitudes, and though area where now is the Gulf of Mexico, there is little doubt that much of the Mississippi Valley and adjacent states would be as dry as the corresponding region in Australia.

The contrasts are even more strongly emphasized when we compare the "Build" of the arid parts of the United States with that of arid Australia.

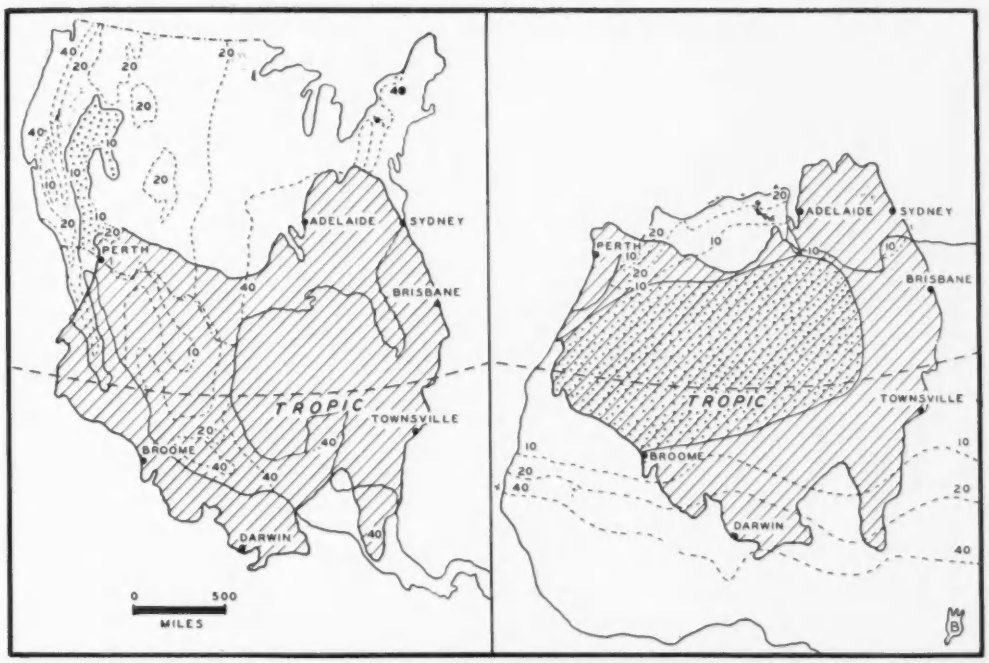

FIGURE 1.—Australia superimposed upon northern North America and upon North Africa. The American and African maps show 150 hyets of 10, 20, and 40 inches. The two dotted areas represent approximately the arid environments in U. S. A. and Australia. (From *Geographical Review*, 1926.)

some 450 miles on the eastern coasts are humid, the remaining 1,900 miles are either semi-desert or desert. South America is narrow (about 1,500 miles) near the Tropic, and its quota of desert is some 200 miles. South Africa is 1,300 miles wide, of which about 800 miles are desert. In North America, Mexico is the true parallel of arid Australia, and the desert in the southwest of the United States is largely of topographic origin. It is seen to lie far on the polar side of the Tropic. However, as stated earlier, if the United States had a large arid land These are illustrated in Figures 2 and 3. In a recent book ("Antarctic Adventure and Research," New York, 1930, page 85) I have shown that the continental build of Australia—on the *west* of the Pacific Ocean—is the enantiomorph (mirror-image) of the American continent *east* of the Pacific. Shield, Down fold, Young Mountains, and Ocean Deep are repeated in opposite order on different sides of the Pacific. It is true that the Australasian Fold-mountains are mostly drowned by the sea, and hardly appear on the mainland of Australia

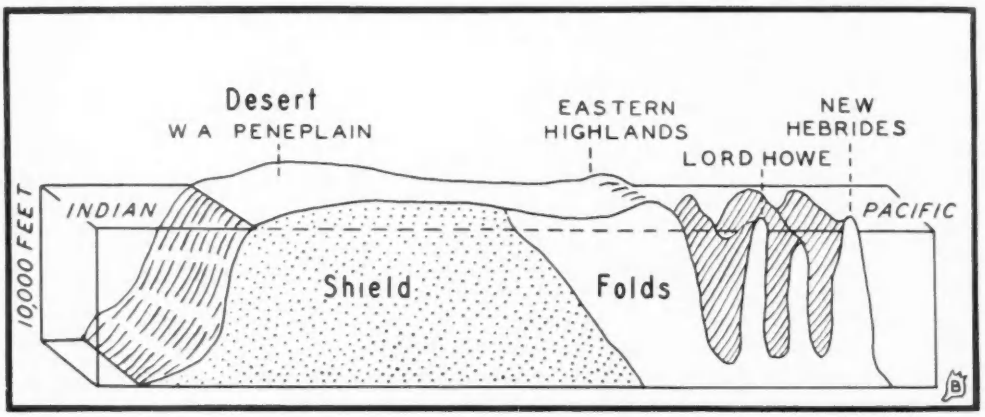

FIGURE 2.—In Australia the western desert area consists of the resistant low, level shield. (Figure 3 is the same scale.)

(Figure 2). In fact, they rise to their chief height in New Zealand. However, it is of the greatest significance that it is the westward, *leeward*, side of the continent which is the arid region in both continents in these latitudes. Hence in Australia the *Shield* constitutes the Desert, while in America it is the Basin, Range and *Fold* area which contains the desert lands. (See inset in Figure 7.) As we shall see, this entirely different build in the two types of deserts vitally affects their environments and potentialities.

In December 1924 the writer made a traverse of the sparselands and the margin of the Desert in Western Australia. About two hundred miles of this journey, from Nullagine to Peak Hill, is illustrated in the block diagram (Figure 4). The geology of this region has been carefully studied by H. W. B. Talbot, and his numerous maps have been published in Bulletin 83 of the Geological Survey of Western Australia (1928). Reference to the block diagram will show that we are dealing with a typical peneplain about 2,000 feet above sea level. It consists essentially of granite capped by fairly level beds of sediments of pre-Cambrian age. These latter form mesa-like structures from 200 to 500 feet above the peneplain. The numerous "rivers" shown in the diagram occur as

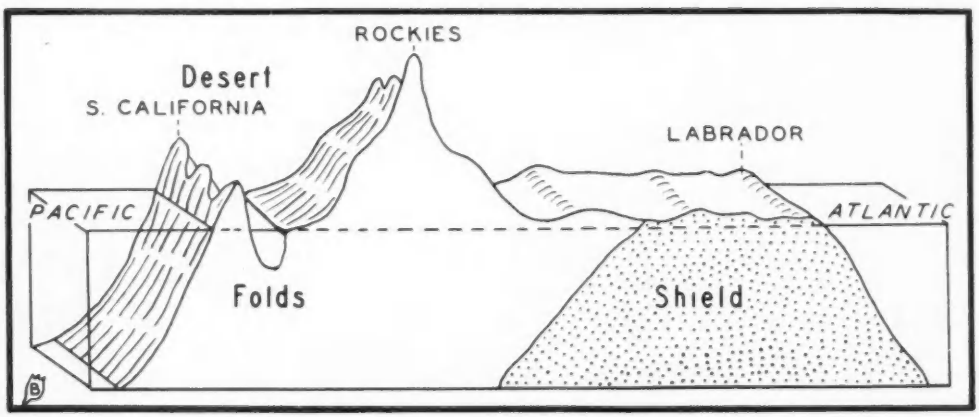

FIGURE 3.—In the United States the western desert area consists of the young folded elevated mountains and basins.

vast "senile" expanses of gravels, and they rarely contain any surface water. However, some ground-water is present fairly generally in arid Australia, and small wells have been dug every ten miles or so along the main stock route for the benefit of traveling stock. These are indicated by small circles in Figure 4. The chief "stations" (ranches), such as Noreena, Ethel Creek, Mundawindi, and Ilgarerie, are shown on the diagram.

In the following account of the physiography of the region between Marble Bar and Peak Hill (Figure 5) it must be remembered that my journey took place in the height of summer. In the preceding summer (1922–3) Marble Bar (near Nullagine) had experienced 152 days in which the mean maximum was 109° F. On Christmas day 1924 the writer was in Nullagine and the thermometer rose to 119° F. Indeed, it was a bad drought season, and we carried sixteen bags of grain in a trailer behind the Royal Mail, which was an old Dodge car. This fodder was brought from Perth to these outback ranches in the effort to save some of the best stock.

From Nullagine southward to Noreena we traversed a stony hamada with a little "wind grass" between the sheet waste. There was a good deal of spinifex (i.e. *Triodia*, a spiny tussock grass) and shrubs called kandjai, a *Grevillea* resembling gray holly. In the shallow creek-beds—all, of course, dry for many months—white gums (*Eucalyptus* sp.) were fairly numerous, their roots reaching the deep wet gravels. Mesas were numerous each side of the stock route as shown in Figure 4.

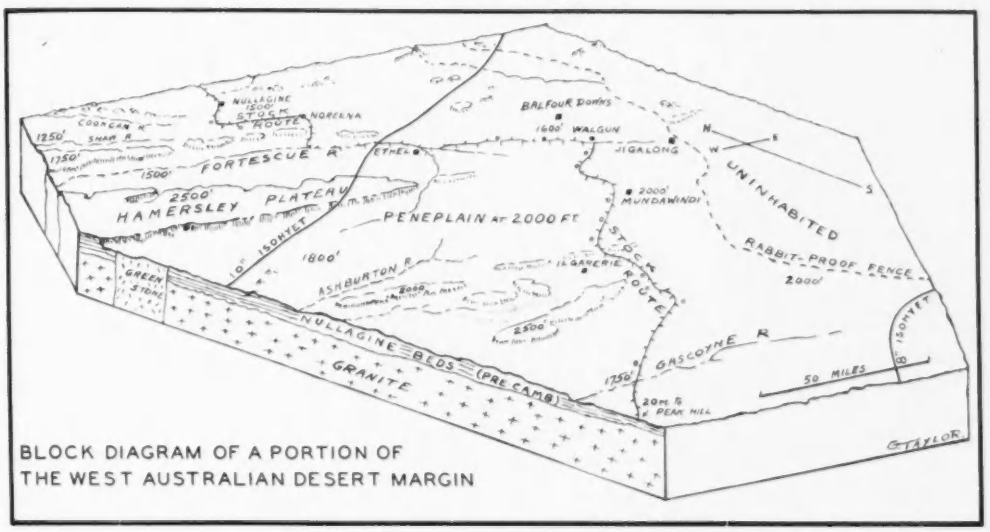

FIGURE 4.—The rivers do not contain water except after very rare heavy rains. (Based on H. W. B. Talbot.)

South of Noreena we passed belts of mulga (*Acacia*) with some Broombush (*Eremophila*), and then reached more spinifex and needlebush (*Hakea*). This continued to Roy Hill Station. Near Walgun we crossed Jigalong Creek (a wide expanse of drifting sand) in which the car stuck for some time. In general, however, this gravelly hamada needed only to have the bushes cut away here and there to make natural, if rough, motor roads. The Tropic of Capricorn runs through Jigalong, which is also right on the Rabbit-Proof fence. This famous fence is the inner (eastern)

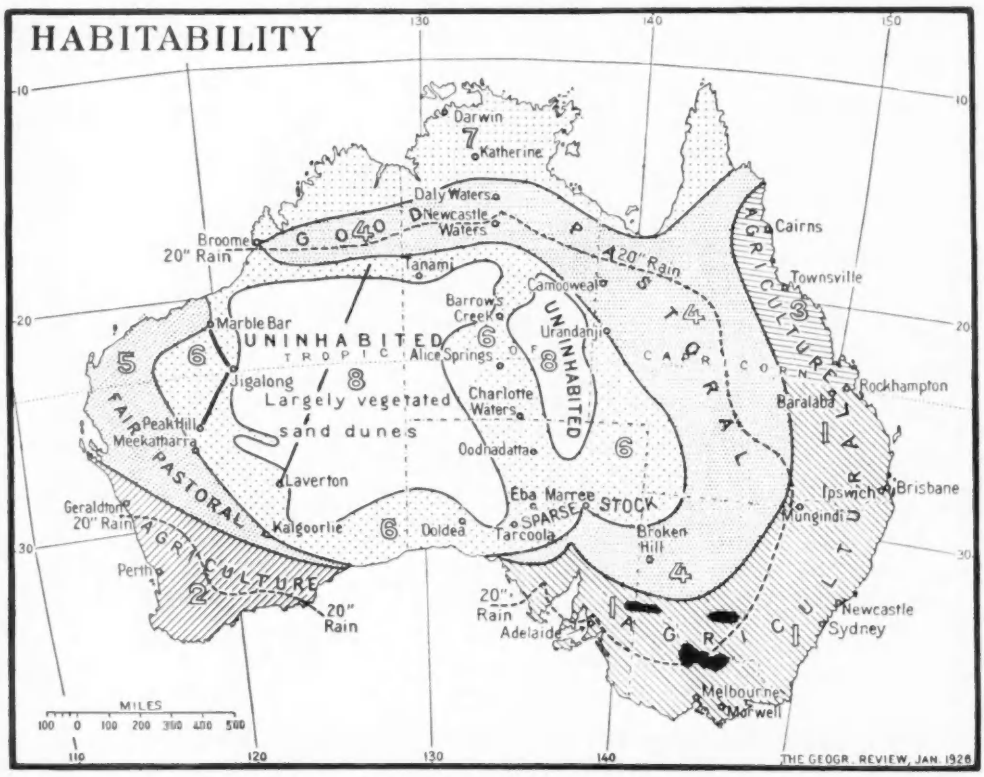

FIGURE 5.—Pastoral possibilities of Australia. The areas labelled 1 to 3 are the possible croplands. The remaining regions 4, 5, 6, and 8 approximately correspond to similarly labelled lands in Figure 6. The three black areas include 90 per cent of the irrigated lands. The two broken lines (in the west) indicate the traverses described.

boundary of the "sparseland" in Western Australia. At Jigalong there was formerly a government station for breeding camels, but this project has been abandoned.

At Balfour Downs (shown in Figure 4) is a fine homestead, with walls built of pisé-mud, and with the usual grass lawn kept green by constant watering from the well. In this case the lawn was about ten feet square. The enterprising manager had little patches of lucerne (alfalfa), Soudan grass, onions, tomatoes, and even watercress grown with the same water. His wife, with her two small children, was isolated by a hundred miles from any white woman; and I cannot refrain from expressing my admiration for such gallant pioneers. The next station, at Jigalong, was much smaller. Here the long low sand-ridges of the uninhabited country (by the ranchers themselves known as "desert") could be seen from the house. As usual, they were "fixed" or vegetated, by mulga, waxy spinifex, and other scrub; but they indicate country where the feed is too poor and the water too precarious even for such sparse pastoral occupation as exists west of the boundary. Such an environment the geographer also calls a desert.

From Jigalong our route crossed a number of low sand-ridges, where the sand was drifting somewhat, but thence the country to Meekatharra contained rather poor mulga, with much rocky débris and large patches of spinifex and a little saltbush. We soon rejoined the great stock route, where government

wells have been sunk every dozen miles. At Mundawindi we reached the government "rest-house," and here a fee of one shilling (paid to the postmaster) gave one the use of a cowhide stretcher. "Wild apple" bush (*Canthium*) and "pitch" bush (*Eremophila*) were interspersed with mulga in this region. Near the Gascoyne Divide another series of sand-ridges was seen, with a mallee flora (*Eucalyptus* sp.) like that of the far south. In the evening we reached Peak Hill, now a stagnant town of about a score of houses, surrounded by bygone mines.

The character of the central uninhabited area (8 in Figure 5) may be gathered from Carnegie's account in

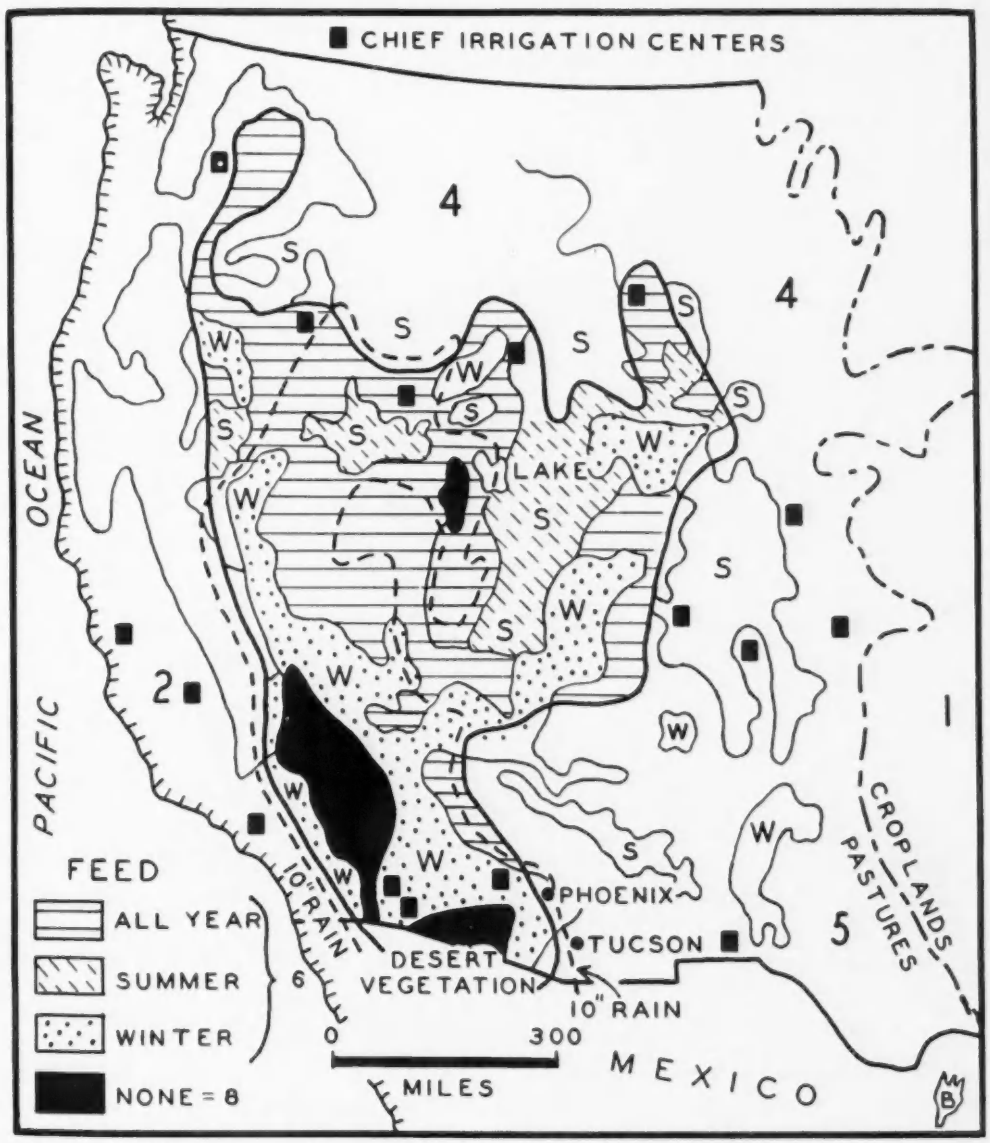

FIGURE 6.—The heavy line shows the limits of desert vegetation in western U. S. A., according to Shantz and Zon. The broken line shows the ten-inch rain line. The large figures correspond approximately to those shown in Figure 5. (Data as to feed for stock based on A. F. Potter.) (Map after O. E. Baker.)

"Spinifex and Sand," London 1898. Leaving the southern goldfields near Laverton in 1896 he met the first sand ridges at 26° S. They extended northeast for 420 miles (Figure 5). They were from 30 to 50 feet high and ran very regularly from east-by-south to west-by-north. Belts of mulga forming dense thickets, and other specimens of small trees like acacia, quondong, etc., grew sparsely in the hollows. He describes much of it as a great undulating desert of gravel formed largely of pebbles of ferruginous sandstone.

No stock graze in the two areas labelled 8 in Figure 5; and hence there are no settlers. It is the lack of suitable vegetation rather than lack of water which prohibits ranching, for Canning found ground water at sufficient intervals to water a "Stock Route" across the northwest corner of the main desert. However, this stock route has rarely if ever been used for its original purpose of bringing cattle from Halls Creek in the north to Wiluna near Peak Hill (Figure 5).

Australians are apt to imagine that the desert areas may be exploited by irrigation in the future. Probably they base their opinions on what has been done in the United States. The conditions are so different that no parallel exists between the two cases. In the deserts in Australia there is nothing which can be called a river. Only for an hour or two after an occasional heavy thunderstorm a gully may contain flowing water. There is nothing even resembling the Mohave River—while the longest Australian river (the Murray) does not surpass a desert-crossing river like the Colorado. The irrigated regions in Australia only total 620,000 acres, and their position is far from the desert lands (Figure 5). The writer doubts if there is unutilized water enough in similar semi-arid regions (which have a rainfall of 15 to 20 inches or thereabouts) to duplicate this area in the future. In the arid part of the United States about 15 million acres are irrigated; so that Australia's area is only four per cent of this total.

Many of the difficulties and disagreements which arise in a discussion of deserts are due to questions of definition. This aspect of the problem I have discussed fairly fully in several publications. It will suffice to state that Koeppen's "Desert" in Australia (5, 6 and 8 in Figure 5) includes a little more than one million square miles—while in the United States he allots about 200,000 square miles to desert lands. The writer has been accustomed to discriminate between the uninhabited lands in Australia (8 in Figure 5) and the borders thereof. The latter districts have a sparse population of pastoralists, and to them he gives the names "Sparselands" (5 and 6 in Figure 5). Thus he divides Koeppen's Desert into about 500,000 square miles of absolute desert and about 700,000 square miles of Sparselands. The latter include a scattered white population of about 15,000 pastoralists.

Considering the area of the Sparselands (5 and 6 in Figure 5) in more detail, they include about 11,000 men, 150,000 cattle, and 2,740,000 sheep in the Western Australian portion. In South Australia there are about 3,750 men, 56,000 cattle, and one million sheep. In the Sparselands of the Territory (between the two deserts) there are about 600 men, 130,000 cattle, and a few thousand sheep. If we consider 9 sheep equivalent to one cow, then the area per cow in this 700,000 square miles is about 640 acres. In the poor Winter-Range districts in arid western United States, a cow needs only 75 acres for its grazing. It is specially to be noted that the Australian Sparselands have been occupied

by ranches for forty years, and that of late years there has been little change in the numbers of the stock grazed there. In other words, the pastoral industry in the Sparselands long ago reached a state of relative saturation. Of course, large areas even in the Sparselands are entirely too poor for grazing, but no map as yet has appeared to specify such useless country.

Turning now to settlement conditions in arid America, it is not easy to make close comparisons. We may perhaps equate the boundary of Desert Vegetation (Figure 6)—as given by Shantz and Zon—with the aggregate of Deserts and Sparselands (regions 5, 6 and 8) in Figure 5. It seems reasonable to use the stock themselves as "indicators" of land values, since neither Australia nor United States are any longer *young* or *undeveloped* pastoral countries. Thus the black areas in Figure 6 represent in general useless salty desert and, according to O. E. Baker ("Agricultural Regions of North America," ECONOMIC GEOGRAPHY, p. 327; Oct. 1931), total about 100,000 square miles. We may

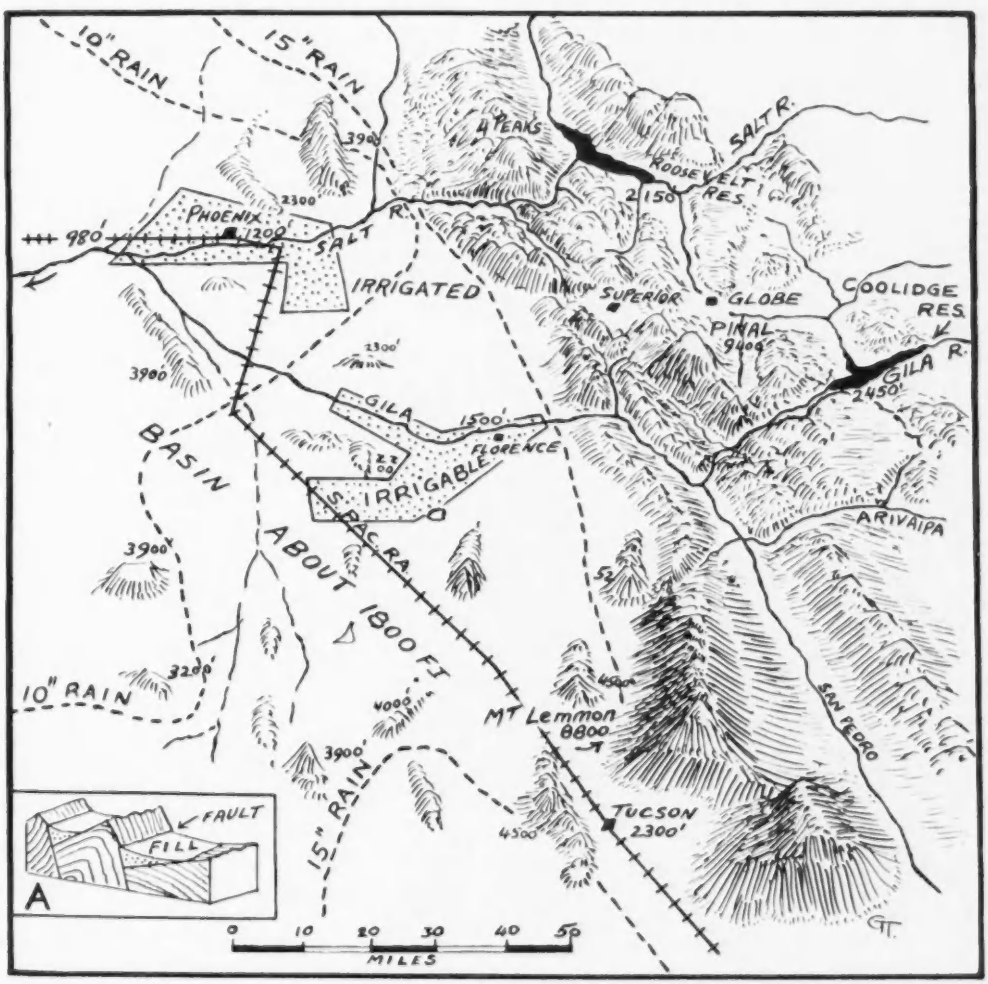

FIGURE 7.—Bird's-eye view of the desert region between Tucson and Phoenix, showing the "Block" mountains rising 5,000 to 7,000 feet above the "infilled" basin. Inset at A is a diagram of the typical "build" of the arid portion of U. S. A.

equate this with the Vegetated Sand Dunes (and Serir or pebble country) shown as 8 in Figure 5.

There is no parallel, however, in Australia for the widespread area used for summer or winter grazing. The former is mainly found in the mountains and is largely due to the melting snows. Since there are no mountains in the Australian arid lands (except a few ranges like the Macdonnells and Musgraves, which are much too low to carry snow) there is no transhumance of this kind. All the region labelled 5 and 6 in Figure 5, where grazed at all, is used the whole year round. Hence the grazing, like the topography, is uniform in Australia, and very diversified in western United States.

In the last illustration (Figure 7) I give a slightly generalized view of the region in southern Arizona which includes Tucson and Phoenix, together with the superb mountains to the east. The writer has done field work in all seven continents, and no region in the world has been more interesting to him as an example of environmental control than that surrounding Tucson. The amazing rocky slopes just a few miles west of Tucson dominated by the giant cactus were of a kind totally unfamiliar to a student of desert conditions in Australia. But even more surprising—one might say almost incredible to an Australian—were the snowclad slopes of Mount Lemmon about the same distance to the northwest. Here, above an elevation of 7,500 feet, appear thick forests of tall conifers whose bases were shrouded in snow. In May 1933 we were almost the first strangers after the previous winter to reach the outlook on the summit. Small streams dashed down the upper portions of the range but dwindled away before they had crossed the middle slopes. Similar ranges are higher and closer-set still farther to the east, and it is such a topography which has produced the Gila and Salt rivers and many another like them. These rivers in turn cutting through the "block" formations (indicated in the inset at A) produce ideal sites for dams. Thus Roosevelt Dam was built in 1911 and Coolidge Dam in 1930, and the former waters about 300,000 acres around Phoenix, and the latter some 100,000 acres near Florence (Figure 7).

The following table shows the enormous areas irrigated by four American rivers. Only one Australian river basin, the Murray, has any large amount of water for irrigation and its quota is only about 500,000 acres.

CHIEF IRRIGATION AREAS IN UNITED STATES

Basin	*Acres*
Missouri	4,185,180
Columbia	3,393,640
Colorado	2,537,124
Rio Grande	1,468,913

Thus there is little resemblance in the resources of Australia and the United States, though their areas are almost identical. However, as the writer has shown elsewhere, the southeastern non-arid portion of Australia offers perhaps the best field in the world for a limited number of white settlers among the many lands which still remain in a relatively undeveloped state. But that is another story!

RAILWAYS AT THE HEAD OF LAKE SUPERIOR

George H. Primmer

THE head of Lake Superior long attracted attention as a prospective site for a commercial city of consequence. Only a scant population lived about the lake head and only a meager trade developed before railways connected interior areas with the westernmost portion of the Great Lakes water route. This paper details conditions influencing routing of roads focusing on Duluth-Superior (Figure 1).

Lake Superior and Mississippi

"Portage" railways receive first consideration in many areas. Typical Minnesota early plans included a line between navigable Mississippi waters and the head of Lake Superior. A writer of 1850 suggested the use of St. Louis and Savanna valleys to the navigable river at Sandy Lake, with an alternative route connecting the head of the lake to navigable St. Croix. In 1853 the legislature authorized a road between some convenient spot at St. Paul and a point near St. Louis River falls. A St. Paul colony in Superior worked so valiantly for rail connection with the mother city that in 1854 the Minnesota legislature granted land for a road to terminate on Nemadji River on Wisconsin side of the lake head.

A location survey north from Hudson on St. Croix River followed Eninandigo, Black, and Nemadji valleys. It was estimated that the cost would be $13.00 per ton from New York to Hudson over such a route whereas it would be twice as high by way of Chicago. Since Lake Superior head lay only sixty miles by water farther from eastern points, many expected a port rivaling Chicago soon to develop there.

Of ten lines early chartered to Superior City none materialized, but their planning enticed a considerable population. As soon as a contract to construct one road became binding town site shares sold at 100 per cent advance. When equipment for making a pioneer wagon route south from Superior landed, and promoters erected docks and warehouses at Nemadji mouth, the thirteen original shares in Superior sold to ten times the earlier sales figure of $1,500 each. Persons interested in a line 76 miles longer between Lake Michigan and Mississippi River bought off contractors working at Superior, and their work ceased well before the 1857 panic.

Favor shifted to the Minnesota side of Lake Superior head, but not primarily to serve the few persons residing there. Six of twenty-seven territorial charters contained "Lake Superior" in the company name. Upper Mississippi Valley population feared the closing of the Mississippi lower course in event of a north-south division of the country. Interior Minnesota farmers could then rely upon a shorter route to Lake Superior than to Lake Michigan, and eastern goods might reach Minnesota points four days sooner at a saving of as much as $12.00 per ton. In 1861 a Minnesota state publication advocated a 120-mile line connecting Mississippi River south of Anoka and St. Louis Bay of Lake Superior. Theoretically, such a road would place the state on a parity with Wisconsin and Illinois with their outlets to Lake Michigan. Easier marketing of downstate Minnesota cattle at Michigan copper towns constituted an argument currently used for a railway to the lake head.

Wheat growers of Blue Earth County alone estimated potential savings of $137,000 annually. Pending a road north, state officials advised farmers to produce wool commercially since it weighed only about one-twentieth as much as wheat of equal value.

An 1860 preliminary survey into Duluth showed grades from Fond du Lac vicinity less than anticipated, a finding highly pleasing to Duluth dwellers. The next year a swamp land grant of nearly 700,000 acres required grading and construction to begin at some convenient point at the west end of Lake Superior and thence to follow the most feasible route to Mississippi River. Apparently purposeful omission of the word "Lake" in the bill as passed caused much uneasiness in Duluth, despite the fact that the charter called for a route wholly within Minnesota. Duluth citizens feared establishment of the terminal at Superior City rather than on Minnesota Lake Superior frontage. Superior, lying altogether on Lake Duluth plain, rightly boasted more terminal space than Duluth possessed, but unsuccessfully promoted federal legislation adding northwest Wisconsin to Minnesota.

In 1862 a memorial argued that in case of war with Great Britain, then not unlikely, a Lake Superior railway would prove indispensable. New settlers attracted to the railway zone would repay national government subsidies. Disposal of tributary timber lands promised a likely source of revenue at a time when the federal treasury sadly needed replenishing. Great wartime increases in rates across Wisconsin intensified clamor for a shorter Minnesota agricultural outlet to Lake Superior.

Bonuses fixed both terminals. Late in 1863, following a veto by its mayor, St. Paul voted $250,000 to the road if it reached the river there. St. Louis County, by a majority of one, voted $150,000 in bonds to guarantee the northern terminus upon its lake shore. Of nearly one-fourth of its area granted to aid Minnesota railways the Lake Superior and Mississippi received 862,000 acres. Marshes north of St. Paul suggested grading difficulty. Some insisted that eastern capital would finance only a short cheap route as from Anoka or St. Cloud. Such routes promised way business, lands alongside showing better promise of agricultural development and productivity. Persons of influence no longer hesitated about the lake terminus. Revenue of a port, if within the state, would accrue to the treasury of Minnesota.

By the close of the Civil War thirty miles of graded roadbed extended from St. Paul to Wyoming. Minnesota promoters hoped thus to convince Philadelphia capitalists of their sincerity. With a view to speculative profit they also purchased many parcels of land in Duluth and elsewhere along the route. Their engineer recommended completion of the entire grade and bringing of steel over the lakes, with use of Fond du Lac as temporary terminus. Plans called for a later extension to an outside breakwater off the Portland division of Duluth, though the company president suggested an artificial passage to an inner harbor back of Minnesota Point. In 1866 a prospectus of Minnesota Valley Railroad Company promised a connection, St. Paul to Lake Superior. A German book listed the road as a potentially cheap emigrant route, St. Louis River mouth lying 400 miles nearer Atlantic Ocean than St. Paul, as measured by way of Lake Michigan.

Superior's interests, Duluth citizens alleged, disconcerted capitalists about to push the road through by again raising the question of lack of room for a railway and terminal and calling attention

to waterfront swamps. Interested persons arranged a detailed topographic survey of a wide strip paralleling Duluth shoreline that effectively allayed fears of Philadelphia investors. Jay Cooke visited Duluth, traveling by boat from Superior, to secure terminal area for the road. He inquired in detail concerning river navigability, the land-locked harbor, and lake head water depths. Track steamer, while the rest of the party used ten platform cars.

As the road approached, Duluth, designated by charter as the lake terminus, included only around 100 inhabitants. Superior then boasted several times the population. South shore interests organized the Superior and State Line Railroad and planned building from Superior to Carlton vicinity. There

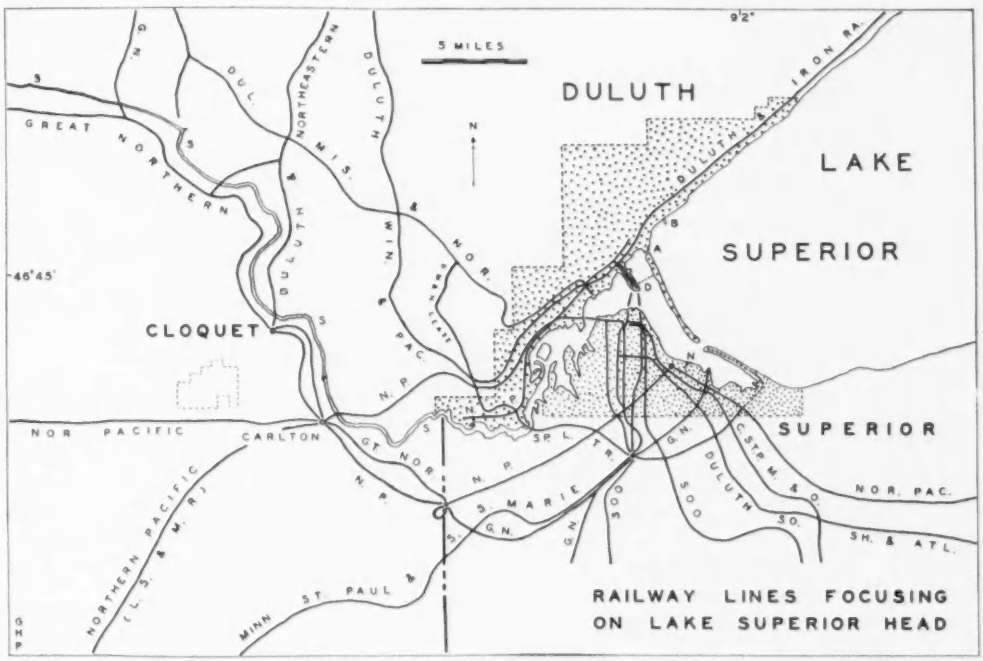

FIGURE 1.—Devious approaches to Duluth waterfront reflect handicap of the north shore scarp. (A) artificial entry to Duluth end Superior Bay; (B) breakwater remnant (elevator "A", 1870, stood at shore end of 900-foot sheltered section of lake); (D) dike designed to prevent St. Louis River water entering lake by way of Duluth entry; (N) Nemadji mouth site of early Superior settlement opposite natural lake entry; (S) St. Louis River of which the valley offers a comparatively inviting approach to Duluth-Superior harbor.

laid in 1868 extended to Kanabec River, and a delegation of Philadelphia capitalists journeyed thence to Duluth, using the "military" road by way of Twin Lakes and boat from Fond du Lac. They paid $5,000 for a terminal site, improved lake frontage at Minnesota Point base, where they planned an outer harbor. The same autumn 500 railway company guests rode to a picnic at White Bear, the ladies in four coaches, two recently arrived in St. Paul by Mississippi

they expected to intercept the business of Lake Superior and Mississippi and divert it to Superior City. Abandonment of the plan left the Wisconsin port with no direct railway service for about twelve years.

Jay Cooke readily sold $4,500,000 gold bonds on the security of the road approaching completion, the rolling stock, and some 1,600,000 acres of land near the line. Five feeder roads, he suggested, could save perhaps 20 cents

per bushel by using his route which was 290 miles shorter. A personal representative of Cooke visited Duluth and spent $9,000 for town lots for the financier. Investors received warning that the venture would not pay dividends at once, for early completion would serve only to perfect land grant titles. They succumbed to such tales as a report of immense slate deposits near Duluth, mostly on railway lands, which when developed would provide, promoters estimated, more than half a million dollars of revenue annually for the new carrier.

With work beginning on the north end of the line in 1869, population of Duluth increased rapidly (Figure 2). Laborers received two dollars per day and a railway agent in lower lake ports procured workmen and immigrants. The steamer *St. Paul* carried 220 hands for construction work with the first railroad iron from Erie. The small school population of St. Louis county much more than doubled in a year making new buildings necessary, and in two years two to three thousand people had immigrated. A construction train brought 300 men from the south to blast a roadway in rock of St. Louis Dalles. Most employment offered, aside from work on the railway, was in woods and sawmills. A bank, associated with Cooke interests, opened for business.

A $1,250,000 contract covered the 35 miles from Duluth to ten miles beyond St. Louis Falls. At one time 850 men worked, driving nearly 1,800 piles to support the road along the marshy water front. They cut through high bluffs, rounded jutting points with curves up to seven degrees, and filled extensive marshes. Another crew worked on the telegraph line paralleling the railway. The meandering route followed the St. Louis nearly enough to permit schooner delivery of subsistence stores and other materials to camps near the river.

Rapid growth of Duluth, accompanying completion of the railway, coincided with the dullest period in the life of Old Superior. Its editor, craftily eluding creditors, ferried his equipment across the bay to do business in Duluth. Chiefly old, or decidedly youthful, persons remained on the south side of the lake head and for some time the strangely assorted population remained hard put to it to support itself. The first St. Paul train reached Lake Superior at Duluth August 1, 1870, in 16 hours, about four times the present schedule. A St. Paul resident wrote of the innovation, "thus giving our city a connection with the great lake system which has been an incalculable advantage in its commerce." Governor Marshall reminded the legislature that Duluth, both town and harbor, took on new importance as the only available Minnesota lake port. Actually for some downstate areas, the chief value of the lake route remained for a long time the regulation of rates on optional railway routes. Business of 1870 gave a net income slightly more than one per cent of the nearly $6,000,000 capital investment. Most goods received at the Duluth rail dock went south by train. Nearly all incoming flour and wheat and all scrap iron left Duluth by lake.

Settlement succeeded the new railway more largely along its southern portion. Early advertisements, telling of possible savings in shipping wheat and other advantages, brought many immigrants from Europe. A Swedish publication in 1872 refers to one-fifth the railway grant lands as suited to agriculture. Settlers bought 40 or 80 acres making very small early payments, when normally they cleared fields. A New York office supplied prospects with maps and views and displayed a collection of products of the area tributary to the road.

A booklet advised Germans of the

cheapest and most convenient emigrant route to interior Minnesota. The railway agreed to carry purchasers of its lands, their families and luggage, at half price and shelter them free at Rush City and North Branch until the settlers built houses. Land prices varied with quality from three to six dollars per acre, with a reduction of one dollar per acre quoted for each four miles distance from the road.

Settlers readily sold forest products to the railway company or worked in the woods for hire. Locomotives loaded immense supplies of firewood at stops en route; passengers, at times helping, relieved journey tedium and hastened train departure. After operating for fifteen years, the road still used between three and four times as many cords of wood as tons of coal.

Though all iron and steel came from the east, much local material entered into construction of the railway and the jointly used terminal at Duluth. Contractors purchased pine near Oneota and cut it for piling. They constructed a timber-crib outside breakwater, procuring crib filling from the gabbro bluff not far from the shore end of the dock. The Northern Pacific dike, separating Duluth and Superior ends of Superior Bay, consisted largely of piling from the nearby forest. It was built in winter, holes being cut through harbor ice before the piles were driven.

The Lake Superior and Mississippi Railway, despite considerable income from freight, plus that from passengers and from land sales, defaulted bond interest and reorganized in 1877 as the St. Paul and Duluth. The first lake head railway helped Duluth grow to several times the size of Superior and in part explains its present leadership. Normally, grain and flour have constituted a great share of northbound tonnage, while at times the major share of southbound tonnage consists of coal, no usable coal lying within Minnesota.

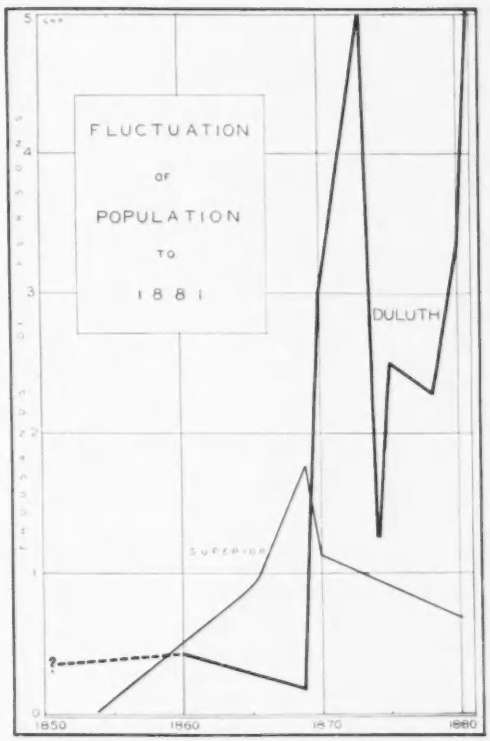

FIGURE 2.—Assurance of a railway terminating at Duluth attracted many people there. Superior, for more than a decade at lake end of the "military road" from St. Paul, suffered serious population loss.

Early railways, in general, discriminated against Duluth in favor of Lake Michigan and Mississippi River cities until largely forced from the practice by the Interstate Commerce Commission. Duluth resents the proprietary interest connecting railways give the "twin cities," Minneapolis-St. Paul, in its harbor. Especially distasteful to Duluth is the attitude of the twin cities that it is only their auxiliary, a somewhat remote suburb desirable only for the lake transportation offered.

In 1879 a six-mile extension reached Knife Falls of St. Louis River and thus made possible development of the forest industries city of Cloquet, included in the lake head metropolitan district. A "Short Line" entrance into Duluth, be-

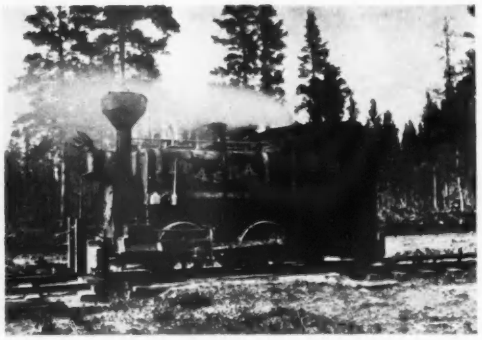

FIGURE 3.—Early Northern Pacific locomotive in Duluth area, probably photographed before road penetrated Red Valley.

sides reducing mileage, also reduced the maximum grade from 103 to 52 feet per mile, eliminated many curves, and avoided numerous places requiring bridges.

After almost complete loss of tonnage in forest products, the autumn peak of earnings increased. Though some way business amplified income it remains a small share of the total. For a long time total business did not suffice for great profits, but after twenty years, even with three competing lines, business available led interior roads to try to purchase the St. Paul and Duluth as an outlet to Lake Superior. With its numerous short branches the Northern Pacific purchased this first railway reaching Lake Superior head and since 1900 it functions as part of that system.

NORTHERN PACIFIC

Duluth played a minor rôle in the inception of its first railway, but she had no part in earliest plans for the second railway terminating on Lake Superior head, for its corporate existence was antedated more than two decades. Numerous projected northern route transcontinentals early received support, and at least one plan included a Mississippi River take-off from Prairie du Chien.

Some six years before extinction of the Indian title to the Duluth site, a protagonist, in a Boston speech, outlined northern route advantages: (1) between Puget Sound and Lake Superior measured minimum "transcontinental" distance, (2) intervening low mountains offered comparatively easy crossing, (3) there were no deserts, (4) the route traversed territory well stocked with water, timber, and stone, and (5) nearly all lands not of agricultural value invited grazing or mining.

In 1853 Minnesota's legislature ambitiously chartered a road between Lake Superior head and Pacific Ocean. The charter authorized a $50,000,000 capitalization but its recipients built no railway. Publications of the time drew heavily on Lewis and Clark expedition journals emphasizing lightness of snowfall along the route and low passes between basins of Missouri and Columbia. Printed isothermal maps likely served to correct false notions of winter severity in territory tributary to the proposed road but, apparently, led some to overoptimism. Those who later thought the Northern Pacific had over-advertised productivity of its grant lands derisively referred to them as "Jay Cooke's Banana Belt."

After the Englishman, Oliphant, visited the lake head soon after settlement of Superior, he wrote: "The enterprise which lies nearest the heart of every Minnesotan is the railway to the Pacific." Since some advocates of a northern road already conceived of two eastern termini, one diverging from the other at Red River to reach Lake Superior, Oliphant possibly referred chiefly to persons met in St. Paul. The Stevens survey followed orders to work westward from some point on the upper Mississippi.

California gold for some years made difficult the task of keeping the northern route before the public. In 1857, however, Washington Territory incorporated the Northern Pacific Railroad and

Minnesota the Lake Superior and Crow Wing Railroad Company. Although they joined no bands of steel to link navigable waters, and construction started at neither end of the route, the two companies served best in keeping the matter prominently alive. Stevens emphasized before the American Geographical and Statistical Society the low aggregate of ascents and descents along the route of his survey. Another publicist stressed the invitation of the Great Lakes water route, extending far into continental interior, as a proper natural basis for a system of western roads. A line connecting Lake Superior and Puget Sound, he declared, was the most obviously needed supplement of the waterway.

Wilkinson of Minnesota got a bill through the Senate in 1860 providing a $25,000,000 subsidy and a land grant for such a "Grand Portage" railway. With more education on advantages of the route, Congress later passed a similar bill which President Lincoln signed July 2, 1864. By that time fewer persons advocated a northern rail-river combination using streams along the route which were at that time listed as navigable. Estimates of total Pacific to Atlantic trade reached $400,000,000, and many hoped to route a goodly share over the Northern Pacific.

Citizens of the little hamlet of Duluth doubtless studied the problem, for their scanty pioneer public library included the four volumes of "Explorations for a Railroad to the Pacific." Superior, lying on the same harbor as Duluth and having possibly eight times the population, confidently expected any Lake Superior road to terminate there. One survey party worked from Bayfield towards Superior, and another from Superior westward to Crow Wing on Mississippi River. A map made in 1869 shows Superior as eastern terminus of the proposed road. The chief engineer apparently considered routes to Ashland, to Superior, and to Duluth. Hoping to sell much more at a high price, promoters of the Superior town site offered to give the railway board of directors only about two acres of waterfront land. Minnesota's legislature required at least a branch line to navigable Lake Superior waters within the state.

Estimated average cost per mile exceeded $46,000. One could not reason-

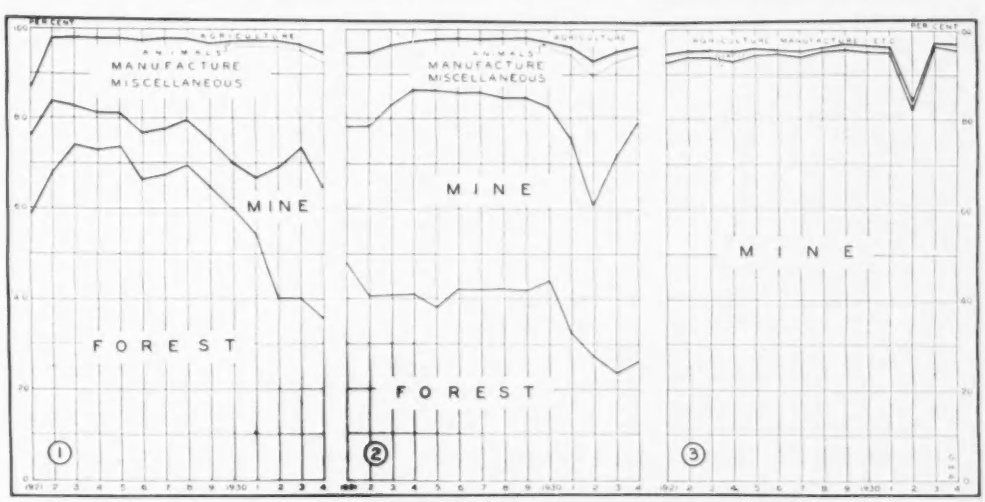

FIGURE 4.—Percentage distribution of types of commodities carried by three lake head railways: (1) Duluth, Winnipeg, and Pacific; (2) Duluth, South Shore, and Atlantic; and (3) Duluth, Missabe and Northern (for more recent years includes Duluth and Iron Range).

ably have expected immediate profits. Financial arrangements, almost perfected in Europe, were disrupted by Napoleon III in his attack on Germany. For selling bonds in United States Jay Cooke received ample compensation. He retained 12 per cent of income from sale of bonds promising 7.3 per cent interest, besides receiving a quantity of stock for each block of bonds sold.

With perfection of the title to its large land grant, of which some 3,000,000 acres lay within Minnesota, and with more than $5,000,000 bond money in

FIGURE 5.—Tunnel entrance for "Soo" line trains about one-half mile southwest from passenger station.

prospect, the Northern Pacific began construction in 1870. About seventy-five persons, mostly lake head denizens, assembled at the Northern Pacific Junction (Carlton) on February 15th and ceremoniously began roadbed construction westward. A resident of Superior pushed a wheelbarrow of earth and dumped it after a Duluth citizen loaded it.

Before the close of 1870 "Junction" deserved its name. Trains plied between Mississippi River and Lake Superior and a 50-mile rail line extended west, where for a thousand miles not even a hamlet existed (Figure 3); civilized men lived only at military posts, Indian agencies, and trading stations. Through its bureau of immigration the railway planned settlement, provided manufactured portable houses from forested lake head area, and contemplated colonies from such places as Massachusetts industrial cities. Settlers received terms of sale similar to those for land between St. Paul and Duluth. One propagandist for the railway contended that their land not only ranked above that along other transcontinental lines but that the climate would attract and breed a superior race of men.

Construction proceeded more slowly than anticipated by land grant terms but contractors attained Red River the second summer. To meet technical requirements the Northern Pacific bought a half interest in the Lake Superior and Mississippi line between Carlton and Duluth. For many years Superior and Wisconsin, denied direct Northern Pacific service, and hampered by costly litigation railway, sponsored harbor improvements on the Minnesota side in Duluth.

GREAT NORTHERN

When James J. Hill began evolving the Great Northern system, his program emphasized building and operating roads northwest from St. Paul-Minneapolis, upon the margin of, or well within, prairie area. Eastward his connections by way of Chicago made possible good winter service to the Atlantic seaboard. Since Lake Superior made possible a much shorter lake-rail route than by way of Chicago, and a much cheaper summer route eastward than elsewhere offered, he soon acquired the Eastern Minnesota from St. Cloud to Hinckley, and arranged for use of the St. Paul and Duluth from Hinckley to Lake Superior head. In the late eighties he extended the Eastern Minnesota 70 miles, the distance between St. Cloud and the lake. Considerable difficulty was encountered in Duluth concerning (1) retaining walls where contractors made cuts along the

hillside, (2) proper waterfront access, and (3) privileges of crossing avenues, and led Hill interests to build two large elevators and a merchandise dock at Superior.

Duluth citizens fostered a road early planned to lead from the lake head far into Canadian northwest prairie area which many then believed would unite with United States. Minnesota granted land in 1878, but twelve years later only 75 miles of road extended northwest from Cloquet into forested area near Grand Rapids. With Mesabi development as a spur the iron ore area was tapped, but this failed to result in either immediate sustaining business or St. Louis County funds. Hill interests took over the bankrupt line and constructed a connecting link between Fosston in the wheat area and Deer River in the forest. Thus they formed a continuous Red Valley-Duluth line about 100 miles shorter than the route by way of St. Cloud.

Hill probably saw little reason for two sets of lake head terminals and illustrated his preference for low grades as well as his choice of ports by abandoning the line into Duluth. To avoid annoying injunction he started a crew one Saturday night upon quick but unostentatious removal of 15 miles of track. Great Northern trains now enter Duluth from Superior over the Connor's Point-Rice's Point bridge. Superior's appreciation of James J. Hill stands symbolized in his statue on the high school grounds, of which the counterpart stands at the Puget Sound end of the Great Northern. No great Oriental trade moves between the two for Panama Canal did much to shatter that vision of the "Empire Builder."

FIGURE 6.—Dog teams early used for winter transport beyond Duluth railhead. Similar conveyances occasionally yet serve in northeastern Minnesota areas far from railways.

CHICAGO, ST. PAUL, MINNEAPOLIS, AND OMAHA

In 1856, soon after a land grant had been made for a railway from navigable St. Croix to Lake Superior termini at Bayfield and the lake head, contractors started grading south of Superior City. After much reorganization and other delays, new contractors in 1883 completed roads approximating the original project. The Duluth and Superior Ferry and freight line of steamers extended service across Superior Bay to Duluth making four round trips daily to meet all trains when ice did not interfere.

Owners soon extended the railway to Connor's Point, and by bridge to Rice's Point in 1886. Places near the lake head then could use a shorter rail connection with Chicago and eastern points than earlier offered. After buying an expensive right of way into Duluth, the road built water front docks and ware-

houses and shifted to Duluth much business from Washburn on Lake Michigan. Since the "Omaha" penetrated southwest as far as Nebraska, about equidistant from heads of lakes Michigan and Superior, it established equal rates for corn shipped from there to Duluth or to Chicago, a significant contribution to the promotion of Duluth-Superior lake grain shipment.

Minneapolis, St. Paul, and Sault Ste. Marie

The Duluth, South Shore, and Atlantic, from the Duluth point of view, constituted its declaration of commercial independence from roads leading eastward by way of Chicago. Extending almost directly east from Lake Superior head, it joined the Canadian Pacific at Sault Ste. Marie. This gave Duluth Atlantic seaboard winter access by traversing shorter distance, rather than the greater distance from Minneapolis which had prevailed before 1888.

The railway management extended its line to make it the full length of Lake Superior. Before extension it occupied the same position and performed a similar function to that of a plank road earlier connecting certain iron mines and their port of Marquette. Extension somewhat increased way business of the line, but major incentive for further investment consisted of the vain hope of moving a considerable tonnage, during closed navigation season, of commodities that lake boats carried in summer (Figure 4). Though an independent unit, the "South Shore" line, since 1890, operates under Canadian Pacific control.

Another lake head "Soo" line resulted from a consolidation in 1888 giving continuous line of track between agricultural lands at Portal on the Canadian border, and Lake Superior, by way of St. Paul-Minneapolis. The company later constructed lines making two much shorter grain routes to the lake head. When Cuyuna ore movement developed the "Soo" lines absorbed the Cuyuna Iron Range road.

The entire Minneapolis, St. Paul, and Sault Ste. Marie system continues under Canadian Pacific control. Some Canadians believe that their most logical route, from a strictly economic point of view, between the populous east and the west with its grain surplus, passes through Chicago. The "Soo" route immediately south of Lake Superior finds more possibilities of way business than does the Canadian Pacific on the north, and forms a much shorter route to seaboard than any combination from western Canada past Lake Michigan head.

"Soo" entrance into Duluth proved a rather expensive procedure. Other roads, occupying much of the space between a high gabbro cliff, the "Point of Rocks," and the waterfront, may have tried to prevent the new competition. They offered no satisfactory arrangements for giving the new line harbor access near Duluth "stadtkern" area. Eventually a tunnel about three-tenths of a mile long, through rock beneath a city street (Figure 5), gave an approach to the site where now stands the largest and finest lake head passenger station.

Chicago, Milwaukee, St. Paul, and Pacific

In 1925 this latest of transcontinentals secured track rights into Duluth and established a freight service terminal on Lake Superior head.

Duluth and Iron Range

As early as 1869 interested persons worked for a land grant for a railway between lakes Vermilion and Superior. Not gold but iron resources formed the natural basis of such a grant some years later. Surveys indicated a shorter and otherwise more desirable route to Two

Harbors than to Duluth on the shore of Lake Superior, hence the original line in 1884 terminated about thirty miles from lake head. Possibly construction continued to Duluth only because land grant terms so stipulated. Wholesalers at the head of the lakes found the road useful for distribution into the area served, and others hoped to haul ore to Duluth for manufacture, but tonnage carried between Duluth and Two Harbors remains light. The entire line now operates under lease to the Duluth, Missabe, and Northern.

DULUTH, MISSABE, AND NORTHERN

The Merritt organization first built a junction with the Duluth and Winnipeg between its mines on Mesabi Range and Stony Brook, partly, since the latter line delivered ore to Superior docks, and because Merritt interests could not receive satisfactory shipping service. In response to a St. Louis County $300,000 bond bonus, the road was continued to Duluth, to terminate in 1892 on St. Louis Bay at Oneota, site of the original Merritt family settlement. Modern docks now stand in place of the crude terminal of the early nineties.

DULUTH, WINNIPEG, AND PACIFIC

This line extends from Duluth toward Winnipeg, through Virginia, Minnesota, on the Mesabi range, ending at the international boundary. Its comparatively light freight tonnage consists of only about one-tenth ore, but more than one-half forest products. The road gained access from peneplain to lake plain at Duluth by tunneling a southward projection of the gabbro scarp face (Figure 5).

DULUTH AND NORTHEASTERN

Only this railway, built exclusively for moving forest products, still remains in service in lands immediately tributary to Duluth. It terminates at Cloquet, some 20 miles upstream from Superior Bay, but Cloquet forms part of the lake head metropolitan district. Cloquet remains primarily dependent upon forest products, as from its founding. Its builders chose the farthest downstream point to which they could float logs on St. Louis River without probability of great damage in going down over lake plain margin falls.

The Duluth and Northeastern, several years since, ceased paying dividends, but

FIGURE 7.—Where Duluth and Winnipeg trains approach tunnel on route from peneplain down to lake plain.

its owners do not plan to abandon and dismantle it, as has happened in the case of similar northeastern Minnesota roads. Instead, they plan to extend it into Superior National Forest; there they contemplate selective logging on a 55-year cycle, so the railway stands a chance of indefinite survival.

LAKE SUPERIOR SYSTEM OF RAILWAYS

Before any railway served Duluth, promoters of the hamlet envisioned a series of roads focusing there, superior to any group of lines that might concenter on Lake Michigan head. These and later citizens of Duluth displayed maps designed to prove that more of western United States lay nearer to Duluth than to Chicago. They separated the theoretical tributary areas by the perpendicular bisector of a line connecting the dots representing the two cities. Such a map indicated that Omaha possessed a

slight, and Denver more than a hundred mile advantage, in using Lake Superior rather than Lake Michigan. The Omaha connection materialized but not the Duluth, Huron, and Denver. Though other lines reached Duluth from the west, the "Farmer Hines" line, subsidized by Duluth business houses, scarcely got its grade, aimed at Lake Superior head, out of Red Valley; the Ada, Red Lake Falls, and Northern, which was to extend to Duluth, never started construction. Several lines reached the lake head from the south, but the Duluth, Red Wing, and Southern built south from Red Wing and failed to make the anticipated Lake Superior connection.

When railway building speeded up in the early eighties, most of the roads planned in Minnesota included terminals at Duluth. State policy included trying to prevent the Chicago or "Western" lines from dominating the Lake Superior system. The Duluth-Superior roads never attained as great a number as those of the western lines because (1) at first they operated primarily as summer roads, (2) the first winter connections exceeded in length those of the Chicago roads, (3) the Lake Superior roads pass through much territory of low productivity, or through foreign territory, or feel the handicap of foreign ownership or control, and (4) the western lines cooperate much better with other roads to tidewater than the Lake Superior roads do with lake steamer lines. In recent years the Lake Michigan head roads work for relative increases in lake-rail rates greatly to the consternation of shippers of the port of Duluth-Superior.

NAVAJO LAND PROBLEMS

J. W. Hoover

THE casual wanderer through the Navajo country cannot fail to be impressed by the seemingly illimitable spaces, so vast, so colorful, and so varied in form. The inhabitants are not much in evidence, for their widely scattered simple hogans, if not hidden away, blend easily with the landscape. Eastward from the Grand Canyon of the Colorado in Arizona, the Navajo realm stretches to the 108th meridian in New Mexico, and from the Little Colorado River northward to the San Juan River in Southern Utah. The solid block of Navajo reservation area includes 25,000 square miles or 16,000,000 acres. Nine states of the United States are smaller. The real Navajo country—the country occupied chiefly by Navajo—comes nearer to 28,000 square miles, an area larger than Ireland.

Incongruously this vast area set aside for the Navajo Indians, with a density of population of about two per square mile, is overcrowded, though it appears vacant.

The Indian population of the reservation area is estimated to include 46,000 or more Navajo, about 3,000 Hopi, and 100 Piute. The entire white population comprises not more than 2,000 traders, missionaries, teachers, and other government employees. About three-fifths of the Navajo live in Arizona and nearly all the rest in New Mexico, where the density reaches four per square mile. The few Piute live along the San Juan River. Though thinly spread, the population presses hard upon the sustenance power of the area, which has an average rainfall of hardly ten inches and a general paucity of resources. So the Navajo, as ever, clamors for more land, spilling over his boundaries, and squatting or pasturing his flocks upon public domain or other unfenced lands, privately owned.

The crux of the problem lies in the fact that the Navajo has been increasing at a phenomenal rate, while there has been a corresponding decrease in the carrying power of the range. "The vanishing American," as an appellation for the native Indian, has been rendered obsolete by the fecund Navajo tribe, now the largest in the United States. The livestock of the Navajo have meanwhile been increasing at an even more rapid rate than the people.

In 1864, after repeated annoyances by Navajo bands, the tribe was subdued by Kit Carson, and the majority of the tribe, about 12,000, were assembled at Fort Sumner or Bosque Redondo, New Mexico, on the Pecos River. Sickness and disease, with four epidemics in one year, reduced them to 8,000. In 1868 the survivors were permitted to return to their former home. Here they were started out anew with two sheep apiece for every man, woman, and child. A reservation was set aside for them around Fort Defiance in 1870.

Gradually many of the Navajo drifted away to more distant and better pastures. By 1878 they were already clamoring for more land and the first extension was created, which has sustained more Navajo than Hopi. In 1884 the reservation was considerably extended, and except for a few small areas since added, the boundaries remained essentially the same until 1935, when 1,385 square miles, all in Arizona, were added. Actually these additions have merely confirmed the Indians' rights upon lands which they already occupied. Hence

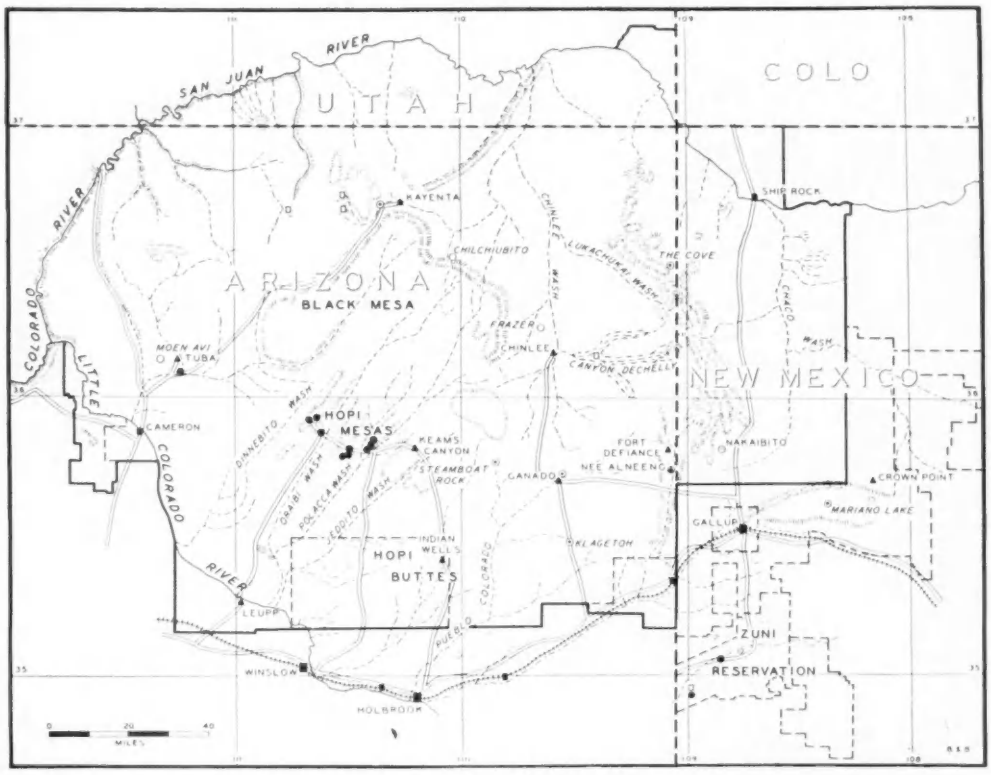

FIGURE 1.—Navajo Indian Reservation with boundaries as established in 1935, at which time 1,385 square miles were added in Arizona. Proposed additions indicated in New Mexico total more than 3,000 square miles. They still await ratification of the New Mexico state legislature.

they may not be considered as having provided in any degree for the expansion of the tribe. More than 3,000 square miles in New Mexico have been approved also by the federal government for addition to the reservation, but so far the legislature of New Mexico has failed to ratify.

The increase of population has far more than offset the areal additions to the reservation. The only real census of the Navajo in recent years was made in 1929 when they were computed at approximately 40,000. Estimates of the population at present range all the way from 45,000 to more than 50,000; 46,000 is a conservative estimate. Early estimates of Navajo population were inaccurate, and at first failed to include the considerable number who had never gone to Fort Sumner. Yet it would appear that there has been about a four-fold increase since 1870. Geometric rate of increase shows no tapering off.

EARLY ESTIMATES OF NAVAJO POPULATION

1872	9,114
1890	17,204
1900	20,000
1906	28,500

The language of the Navajo is Athapascan, so the stem of the tribe must have migrated from the north. Mixed origin is indicated in the tribal physical types which range from the squat solidity of the Pueblos to the tall, sinewy build of the tribes of the plains. Navajo culture reveals the same mixed character. The art of weaving, the outstanding tribal craft, came from the Pueblos, as did many of the Navajo ceremonials. Basketry is strongly Shoshonean. The hogans and also the pottery of the Navajo greatly resemble those of the Man-

dan of the plains. Puebloan somatic characteristics, and the art of weaving, came through the capture of women in raids upon the Pueblos. Also upon the return of the Spaniards, following the revolt of the Pueblos in the latter part of the seventeenth century, some of the pueblo people sought refuge among the Navajo.

A great change came to the Navajo in the years following 1630 with the acquisition of horses introduced by the Spaniards. With horses came rapidity of movement and the transformation of a comparatively peaceful local tribe into troublesome scourge, for now it was possible to attack the Spanish or Indian pueblos and depart like the wind before a counter attack could be launched.

The Navajo are superior physically and in other respects. White people living in the country quite generally appraise them more highly than other Indians. Their neighbors, the Hopi are more progressive, or appear so; but as village dwellers, having for centuries been subjected to the vices and unsanitary conditions of their tight villages, they are a small and inbred people. The Navajo are more reserved, more dignified, and more thoughtful, and the Hopi recognize them as a stronger race. The Navajo will not speak Hopi as they regard it an inferior language, but many Hopi speak Navajo in addition to their own tongue.

The healthy outdoor life and steady activity which goes with the care of their sheep has kept the Navajo strong and fit and has discouraged the spread of disease. The girls are better protected and sex morals are on a higher plane than with most tribes. In late years a large factor in the rate of increase has been lowered death rate, chiefly among infants, due to medical attention.

Many American and Mexican ranchers would rather have seen all the Indians driven back behind the old reservation lines than to see additions made to the reservation areas. These additions, which have been made or proposed, were mostly in the public domain, open to allotment by Indians, or to homesteading

FIGURE 2.—A Navajo family at home. The hogan is an example of one of several types. The manner of laying the logs indicates the white man's influence.

FIGURE 3.—Navajo flocks watering near Crown Point. The sheep are brought in to water every two or three days. In the vicinity of the water holes the forage is overgrazed or tramped out.

by others. They have also included much railroad land, since in order to encourage the building of the Atlantic and Pacific Railroad, now the Sante Fe, alternate sections of land were granted along the route extending back 50 miles. The railroad has been reluctant to release such of these lands as contain minerals, chiefly coal, or to make exchanges for them.

The added areas in Arizona, about 125 square miles west of the Little Colorado River, include approximately 936 square miles of the Hopi Butte country, east of the former Leupp reservation, and about 270 square miles along the New Mexico boundary which is traversed by the Santa Fe Railroad. The proposed New Mexico extensions are all to the southeast and include several detached areas; see Figure 1. The addition of these areas will leave little if any further areal expansion possible for the Navajo.

THE LAND

From the standpoint of utilization, the Navajo country is marginal land. The lower portions may well be classed as desert lands and the highest areas are rather sparsely covered with timber. But no appreciable area is so dry that it does not afford some meager forage, and none is so densely forested that it can not be used profitably for grazing.

The desert areas are less than 5,000 feet in elevation, near the Little Colorado and the San Juan Rivers. Truly barren areas are restricted to those parts which have for ages been subjected to severe erosion by water or wind. They include the very colorful "Painted Desert" areas in the Chinlee Shales, best seen north of Holbrook and Adamana, and between Cameron and the Echo Cliffs; also the inaccessible Rainbow Plateau in the extreme northwest with its maze of canyons cut in red sandstone.

Less than one-third of the Navajo country has any forest cover. About 70 per cent of this is stunted pinon and cedar, mostly scattered, and of no timber value, beyond use for local fuel supply, and limited fence or other rough construction work. These areas can stand a minimum of disturbance. At present they are being reduced by cutting and close grazing, and they show virtually no reproduction of trees. The area of merchantable timber lands is estimated at 720,728 acres, which is about one-twentieth of the area of the reservation. The board footage is estimated to be 1,181,704,000 in Arizona, and 608,727,000 in New Mexico. These figures are mere estimates as no timber cruise has ever been made of the entire Navajo country. At least 98 per cent of the timber is yellow pine (Pinus ponderosa). Pinon pine (Pinus edulis) areas skirt the lower margins of the yellow pine forests. Although not classed as merchantable timber, their nuts are important as supplementing the Navajo food supply or income.

The major part of the country lies

within 5,000 and 7,000 feet elevation and is steppe land. Flat topped mesas rise between broad valleys or canyons cut in essentially horizontal sedimentary rock structures. Red and buff sandstones and sandy surfaces predominate.

VEGETATION ASSOCIATIONS

Locally, vegetation associations vary with soil and topographic situation and are indicators of their character. Scattered pinon and juniper commonly occur on the rocky mesas or ridges, with shrubs and grasses on the lower slopes. Below the pinon and juniper, or extending into it, sagebrush (Artemesia) is the most conspicuous plant. If the soil is not too loose, the blue gamma grass, the best forage plant, grows abundantly if given opportunity. On the lower slopes having more compact soils mixed grasses occur with browse; the latter mostly Happlepapus and Gutierzzia (or snakeweed), which has no browse value, and increases with overgrazing.

A detailed soil survey of the reservation is under way. The soils may be generally classed as pedocals or lime accumulating. So far the only area found to be free of lime is on the top and west side of the Chuska Mountain. Even here the soils are only slightly acid and contain considerable phosphorus. On the Defiance Plateau the soils are dominantly neutral.

Alkaline or saline soils occur along washes and on flats which collect surface water. Greasewood or chico (Sarcobatus) is the most conspicuous shrub on the alkaline areas. It furnishes good browse. Bluestem and shadscale grasses grow with it. On the saline soils, the same plants may occur, but large areas are also covered with saltbushes, species of atroplex. The saltbushes are browsed to some extent for salting. Winter fat (Eurotica), another low, gray-green shrub, is an excellent fattener, valuable for winter forage when other plants are scarce, but unfortunately it does not grow abundantly. The dark green Russian thistle, conspicuous on many moderately alkaline or saline areas, has little forage value, but is eaten to some extent in the spring and early summer while young, if better forage becomes scant.

FIGURE 4.—Navajo cornfield in the Western Navajo Reservation. Navajo methods follow those of the Hopi, but in general they are less painstaking. The Echo Cliffs to the right are of bright red Jurassic sandstone. Flood water irrigation only.

ECONOMIC ADJUSTMENTS OF THE NAVAJO TO THEIR LAND

The tragic bungling of the United States government for many years in

FIGURE 5.—Navajo farming community on the west flank of the Chuska mountain range where the Del Muerto stream emerges from the mountains. Ditch irrigation.

managing Navajo affairs was apparently due to ignorance in Washington concerning that part of the country. Upon their return from Fort Sumner in 1868, heads of families were expected to take up homesteads of 160 acres just as if the land were like the prairies of the Midwest. In the first years, emphasis was given to seeding and cultivation, though a small start was made with sheep and goats. For several years the Indians nearly starved while unsuccessfully trying to sow and reap from lands for which nature made no such provision. Gradually they withdrew from the wing of the government, and returned to the pastoral nomadism into which they had already become adjusted prior to their exile. Thus they became a self-supporting people regaining something of their former self-reliance. As they found satisfactory adjustment to the natural conditions of their land, they prospered with increase—sheep and goats, sons and daughters.

As the population has increased, the old unorganized wanderings in search of the fattest pastures have had to give way to more organized movements, or in many cases confinement to restricted circuits. Around the major highlands, the flocks are driven into the higher timber areas during the summer months and back again to the valleys. In other areas, drier and with less relief, the flocks are driven up in the winter, because then only is water available (in the form of snow) in the higher areas.

Wherever possible the Navajo supplement their grazing industry with a little farming. From the standpoint of sustenance power, the land has been declining at an accelerating rate. Serious erosion of the Navajo lands has set in due to overstocking and overgrazing.

When first the Navajo began to practise livestock grazing, the demands upon the land were not intense. A satisfactory adjustment was worked out to meet the conditions of the area. But the dynamic factor of population increase has rendered their loose organization of land use inimical to the preservation of the range. Passive indifference toward the effects of denudation and depletion of forage resources has aided in lowering the productivity of the land. A finer balance must be struck between the numbers of stock grazing on the land, and its ability to produce forage, in order to avoid a material set-back of the Indians' livestock industry with attendant suffering and loss, even without further population increase.

THE PROBLEM OF EROSION

In the deterioration of the Navajo lands, erosion consequent to overgrazing, is the most serious factor. The chief damage is wrought in (1) removal of the soil and consequent destruction of land or lowering of its productive effi-

ciency; (2) increase in rapidity of run off, which in turn accelerates the erosion process, and increases aridity; (3) lowering of the water table through lowering the bottoms of the drainage channels and rendering drainage more rapid and more complete. The amount of land completely destroyed for productive use in recent years is difficult to estimate, for the injury is relative rather than absolute in grazing areas. If the land were agricultural, much of the destruction would be complete. Reduction of productive value is very apparent and is quite general. Most conspicuous in their destructive growth are the systems of gullies which gash the country. Less noticeable, but no less insidious, are the effects of wind erosion and the more general sheet erosion.

Erosion has been noticeably accelerated in the last half century and has been greatest in the last twenty years. Streams which comparatively recently aggraded their canyon floors are now rapidly trenching their valley fill. Numerous branch gullies have reached out from the deeply cut washes and have intersected the roadway.

Traces of old trails or roads may be found which once followed the valleys, but have had to be abandoned and moved farther up along the valley sides where it is rougher and stonier. Each season necessitates new detours to circumvent the heading of gullies. Instability of the banks due to undercutting of the alluvium discourages bridge building. Even on the main highways travel is often held up, as at Winslow, where the bridge across the Little Colorado was washed out three times during the summer of 1927. Even the Santa Fe Railway had to route its trains south over the Southern Pacific many times for as much as a week at a time on account of washed out bridges.

Into a few advanced major washes great quantities of water are at times poured from numerous tributary washes in all stages of development. Into the great Chaco Wash drain all the arroyos

FIGURE 6.—Young gully with vertical walls near Gallup, New Mexico. Note the large sections of the walls which have sloughed into the wash as the result of sapping.

of the Chaco Plateau in New Mexico. Also leading to the San Juan River are the washes of Chinli, Walker, and Lukachukai Creeks. In the south, the Tusayan Washes, chief of which are the Oraibi, Polacca, Dinnebito, and Jadito, together with the Pueblo Colorado Wash, drain to the Little Colorado.

As late as 1897, the Oraibi Wash was not more than 20 feet across and 12 feet deep at Oraibi according to Lorenzo Hubbel whose relatives have been traders in the country since that time. It now averages 150 to 300 feet wide and 30 to 35 feet deep. The Keams Canyon Wash, now about 25 feet deep, postdates 1880. Its development necessitated moving the government experimental farm and the wash now goes through the middle of the old fields and cemetery. The head washes on the Black Mesa are still mostly narrow enough for the Indians to span with trees, but may be 30 or more feet deep. Until six or seven years ago, the Oraibi and Polacca Washes came together and emptied into a shallow lake before reaching the Little Colorado River; now both have cut arroyos all the way to the river. Between Indian Wells and Holbrook, the Teshbito Wash was easily crossed with a buckboard in 1914, but this became impossible about 15 years ago and the government had to put in a steel bridge.

The upper end of Laguna Creek formerly flowed through a series of small lakes, and was for this reason given its name by Kit Carson in 1863. The last lake was cut out in Laguna Canyon in 1900. On the other hand, the wash at Fort Defiance is said to have changed little since 1892, perhaps due to its emergence from a rocky canyon.

Ganado is called by the Indians "Luka Entiel," meaning wide reeds. For, say the old Indians, the whole valley used to be covered with a heavy stand of reeds or tules, and there was just a small trickle of water passing through the reeds. Today the valley is gashed by the Pueblo Colorado Wash, mostly dry, but at times a raging torrent. No trace of the reeds remains, but instead there is a scant cover of snakeweed or greasewood, except where there are fields under irrigation.

FIGURE 7.—Oraibi Wash several miles above Oraibi. Note sloughing of the bank where sapped due to meandering.

CAUSAL FACTORS OF THE ACCELERATED EROSION

Most students of the problem find in the cultural changes of the Southwest, the reasons for the accelerated erosion of recent years. Prior to 1880, there

was no overgrazing of the Navajo country with its small Indian population. On bordering areas the Mexican people had cattle, sheep, and goats, but there was only a local market. The extensions of the Atlantic and Pacific Railroads through Arizona to the Colorado River by 1883 brought a great increase in the cattle business. Wells were drilled and cattle were put over the country. By 1890 the country was much overgrazed and the grass largely gone.

The Navajo are strikingly indifferent toward their land resources, having none of the peasant feeling and responsibility toward the land that goes with the sedentary Indians. Their destructive exploitation is the result largely of the grazing by an individual family of a convenient radius around the hogan and the return of the sheep and goats to the hogan every night. This results in overgrazing and tramping out the grass, irrespective of total numbers of grazing animals, and probably has done so from the very outset. The radius of the area grazed around the hogan may be as much as five miles but commonly is less. The distance depends upon the individual or family. The sheep are brought in every day and sometimes several times a day. The woman herder may also be weaving, and sometimes brings the sheep in unnecessarily during the day, in order to secure some needed article from the hogan. A few do not bring the sheep back to corrals at night but practise bedding out. The larger herds are generally better managed.

A reduction in the amount of movement on the reservation would reduce somewhat the range destruction. Watering places are as yet too far apart and the flocks have to be driven long distances for water. Navajo herders do not recognize prior rights. They fail to regulate the use of springs and quarrel a great deal over the watering places. Hence many possible springs remain undeveloped for fear others will secure their use. The man with the large herds usually gets control and holds it when pastures are scarce. In the summer the sheep must be taken to the water every two days, in the winter every four days; perhaps 15 or 20 miles unless there is snow to eat. In the summer months the flocks are also occasionally brought from the highlands to the saline flats for salting by feeding on the saltbushes.

FIGURE 8.—The wide flat of the old Oraibi Wash representative of an advanced stage in arroyo development. The present Oraibi Wash has been cut in the alluvium of this older wash since 1880.

Many roadways in the Navajo country have been abandoned, for the ruts, directing the water of torrential rains, have been converted into gullies or arroyos. Horse and sheep trails also tend to start gullies. Not infrequently gullies run along the sides of the valleys instead of crossing the contours directly

FIGURE 9.—Dinnebito Wash. Early stage in the development of an arroyo flat. Note corn patch on small flat under the meander wall on opposite side.

to axial washes following the valley bottoms. The position of former trails is also sometimes indicated by gullies which follow the crests of the ridges. More Indians are securing wagons which is much worse for the range than the use of horses alone for transportation.

Kirk Bryan and H. E. Gregory have held to the idea that the present erosion may be incident to natural causes, perhaps slight climatic change. The major terraces of the Gila and other streams of the Southwest upwards of 75 feet in height are the result of alternate periods of erosion and deposition on a large scale. Remnants of smaller terraces suggest shorter cycles of alternate erosion and deposition within the larger ones; records of still shorter cycles may have been obliterated. Slight periodic fluctuations in climate might account for these terraces. Since the terracing as well as the present erosion is general through the arid southwest, it could hardly be due to diastrophic causes, as in this case the erosion would proceed from the margins of the uplifted area.

The record of rainfall for the few Navajo stations shows no progressive decrease. But Lorenzo Hubbel believes that overgrazing is insufficient to account for the present erosion, and that although there has been just as much rainfall it has come at the wrong time; in general too late to make sufficient growth to hold the soil. Too few data have been kept and over too short a time to be conclusive. The increased meteorological observations begun in connection with the Navajo Erosion Control Project should clarify the problem if kept up long enough.

In view of the present tendencies to lowered productivity, and admitting the existence of earlier similar cycles of erosion in no remote period, it becomes a reasonable hypothesis that areas may have been abandoned in prehistoric times when erosion made them untenable. Thus we may eventually explain to a considerable extent, the mystery of many of the abandoned ruins throughout this region. Furthermore, the relatively dense populations of the regions in the past may have ushered in a series of processes akin to those of the present. A search for correlations between periods of human occupation and periods of erosion may prove fruitful. And if they are found to exist, the land will be seen to have within it the potentialities of healing itself.

Kirk Bryan found evidences of alternation of sedimentation and erosion on the Chaco River or Wash at Pueblo Bonito, New Mexico. Here the Chaco has cut an arroyo 24 to 30 feet deep since 1860. The alluvial deposits on the valley floor include remnants of pottery, charcoal, etc., to a depth of 21 feet, attesting to human occupation during this period of sedimentation. An ancient buried channel was traced for more than five miles. This older channel was evidently formed toward the close of the prehistoric occupation during which the great pueblos were built. Pieces of pottery of very late prehistoric date were found in the channel gravels, whereas

only pottery of ancient date was found at the same depths in the main valley fill. Bryan sees in this evidence of the fact that overgrazing is not the fundamental cause of the late rejuvenation of erosion in the southwest, as these prehistoric people did no grazing. However, archaeologists of the Southwest postulate a similar cycle of devastation through stripping of woody growth for construction and fuel, followed by accelerated run-off, lowered water table, reduced grass cover, and destructive erosion.

Prehistoric ruins dating back 2,000 years, are located in the vicinity of the Nakaibito Erosion Control Experiment Station, on the head of one of the three forks of the Chaco Wash. The extent of the ruins suggests a prehistoric population of perhaps as high as 10,000 in the valley of this wash, living by agriculture in an area where there is virtually none today. Later the Navajo cultivated the flats in the valley below the experiment station. But gullies came in with grazing, and now the main wash has been cut as deep as 50 feet. The gullies drained the ground water and the farms had to be moved farther and farther up the valley until now they have been pushed back to the head of the wash on the mountain divide.

In seeking a solution of the present problem, the natural processes of erosion and sedimentation and also the natural balance between vegetation and animal life, must be given careful consideration.

Young gullies in the Navajo country are deep, narrow, and steep sided. Where the soil and mantle is clay without much stratification, they are likely to be V-shaped. But stratification of thin beds varying considerably in texture is conducive to vertical walls, even in the initial stage (see Figure 6). Such gullies tend to head by notch cutting, duplicating, when they run water, the conditions of receding falls in horizontal strata. More commonly the gully grows in part by the headward advance of a series of low notches until it finally divides into a number of small tributaries. These in turn may duplicate the form and processes of the main gully in miniature, leading into rills which grade into sheet erosion. Such erosion is encouraged in areas of sage or other shrubs which are without grassy cover. The lack of such cover is usually a stage in the process, following removal of the surface soil by sheet erosion incident to grazing, and consequent lowering of the water table. In grassy valley bottoms, the gully heading is usually more spectacular. As the gully enlarges, the

FIGURE 10.—Bad lands between Cameron and Tuba. The bad lands are mostly in the easily eroded Chinlee shales. Thin beds of sandstone and limestone act as binders holding the steep slopes. Owing to the brilliant colors such areas are called "Painted Desert."

banks sag slightly under gravity, especially when pretty well saturated with water. Cracks develop, sometimes as much as 20 feet away. Rain wash entering these cracks enlarges them, and weakens the banks as it seeks its level in the wash. Only a small amount of flow may then be sufficient to sap the banks and cause large sections to slough or slump into the wash. (See Figures 6 and 7.) Much of this slumped material must await a large flood for transit. In the meantime it rests at the base of the steep sides.

On higher slopes silt deposits over the bedrock may be shallow, and even in larger valleys they are not generally so deep as in the arid basins of Arizona and southeastern California. So the valley may be cut to bedrock in places. The Oraibi wash is cut to bedrock about 16 miles above Oraibi and about the same distance below.

While actively widening, the gully banks are unstable, and are a serious handicap to transportation, even dangerous in time of flood. The water table is lowered and the surfaces above are drained of their moisture. In some cases there may be some compensation in a flow of water where the gullies are cut to seepage levels. By way of illustration, in the Oraibi and Dinnebito Washes the flow of water increased as they were cut down, but there has been little change in depth or in amount of water in late years. In the Oraibi Wash there is just a little permanent water at Oraibi, the amount of downwash reaching a maximum at 10 to 15 miles below the village. Increased seepage in the Dinnebito Wash has added materially to the number of springs and the Navajo have changed the name to To-dez-lini, meaning "many springs."

With an increasing number of tributary gullies, the axial washes find increasing difficulty in transportation of the load over the ever-widening bottoms. High vertical silt walls are cut where the current swings to the side of the wash. On the opposite side, the banks gradually slough down and develop rounded continuous slopes. Small flats develop inside the meanders, and gradually the wash widens into a continuous flat. The Pueblo Colorado Wash is entering upon this stage. Above Oraibi, the present or recent wash is cut in the wide flat of an older one (Figure 8). Only in the occasional master floods would the flats be entirely submerged; then except for gradual or abrupt changes in the channel, they would have sediments added rather than removed. The flats may be more fertile than the lands above the bluffs and would be as moist at least as these higher lands ever were. Already small patches of corn are cultivated on the small incipient flats of the major Tusayan Washes (Figure 9). The hazards are hardly greater here than on the land above, where too the Indians find it necessary to shift their fields from year to year with shifting conditions.

Thus viewed, the future of the major washes should present less cause for alarm, since new land as good or better than the old may be built on the widening flats. However a still more advanced stage may be visioned, when the higher slopes of the land would be completely denuded of their soils, in most places thin at best. Then here, as in parts of North China today, the rains would splash against the bare rock mountain sides, and rush off down the gulches as if from bursting dams. Floods would rise suddenly, devastating the country, and subside almost as quickly leaving little or no moisture behind to keep things green.

By checking the run-off and gullying from the head, the banks should slough down to gentle slopes in the absence of the carrying power of the flash torrents.

In the Chinlee and Tusayan Washes drifting sands accumulate opposite the meander-cut bluffs. As an extreme case, Reservoir Canyon, near Tuba, was virtually obliterated by drifting sand. The natural vegetation, if given a chance will help bind the silt and sand drift. Surprising results have already been demonstrated at Nakaibito.

As suggested by Sauer, gravity movement in mass, taking place beneath the surface cover may be predominant in the movement of the mantle. This factor has been commonly overlooked owing to its inconspicuous character as compared to spectacular gullying. While such movement is normal in varying degrees to all slopes, it must be understood in its relation to destructive abnormal erosive processes.

As yet most of our observations on surface and soil denudation, in the Navajo country and elsewhere, have been cursory. Careful research is needed extending over a period of years. In his recommendations to the Science Advisory Board, Sauer has suggested a scientific approach for research in soil erosion.

REHABILITATION OF NAVAJO LANDS

The United States government is attacking the problem of rehabilitation of the Navajo lands and of checking destructive processes on them from several angles. The problem is seen to involve (1) checking of erosion by obstruction of free run-off of water; (2) restoration of the natural vegetation cover and the introduction of plants suited to check erosion; (3) rodent control; (4) reduction of Navajo stock; (5) better distribution of people and stock over the area; and (6) finding or providing other sources of income.

The leading agencies put to work are, in addition to United States Indian Service: (1) the Navajo Erosion Project, under the Department of Agriculture; (2) the Southwestern Station, Erosion and Plant Studies, under the Bureau of Plant Industry; (3) rodent control conducted by the Biological Survey, both of the latter under the Department of Agriculture; (4) Indian Emergency Conservation under the United States Indian Service.

FIGURE 11.—"Nee Alneeng," the new central agency for the Navajo, in picturesque surroundings. Note the "window" in the pink sandstone cliffs.

Until recently the Navajo were governed from six distinct agencies located at Tuba, Keams Canyon, Leupp, and Fort Defiance in Arizona, and Ship Rock and Crown Point in New Mexico. On May 20, 1935, unification of the Navajo Reservation under a single agency was accomplished. The new central agency is located seven miles south of Fort Defiance and takes its name, Window Rock, from the natural window in the sandstone cliffs nearby (Figure 11). It is planned to make this the center of the social, artistic, and religious life of the Navajo as well as of their government. To date the Navajo do not show much appreciation of the capital being built for them, resenting somewhat too much government dictation.

THE NAVAJO EROSION CONTROL PROJECT

The Navajo service includes an experimental area of 67 square miles at Nakaibito or Mexican Springs, located 20 miles north of Gallup, together with

a number of demonstration areas as follows:

Demonstration Areas	*Acres Treated or Affected up to Nov. 1936*
Moen Ave., west of Tuba	10,508
Canyon Diablo, southwest of Leupp	4,864
Pete Springs	23,400
Kayenta	38,223
Chilchiubito, northeast of the Black Mesa	16,586
Canyon de Chelly	3,137
Fraser, northwest of Chinlee	5,553
The Cove, ten miles west of Red Rock	29,376
Steamboat Canyon, midway between Keams Canyon and Ganado	25,000
Ganado, just northeast of Ganado	7,953
Klag-e-toh, 15 miles south of Ganado	3,900
Navajo Agency, at Window Rock	639
Chaco Canyon	3,000
Mariano Lake	7,005

Thirty-seven or more other projects are directed toward specific improvements and are classed as land management.

From the inception of the project and up to June 30, 1936, $3,121,444 had been appropriated by the federal government for the Navajo Erosion Control Project. The Nakaibito area is intended to serve as a center of research for the reservation. It is roughly 20 miles long and five miles wide. Various methods of checking erosion are being tested. Grazing is also being studied from several angles, viz., intensity of grazing, seasonal use, and the number of sheep, goats or cattle that can be taken care of on given types of range and still recover their maximum efficiency of forage and ground cover.

The demonstration areas have also had to do considerable experimenting. Much of the first work at least was far too expensive to be warranted by the value of the land as a factor, but expensive examples on land of little value would appear to have little demonstrable value. Much of the first construction work was admittedly guess work awaiting the test of really heavy downpours. A heavy rain on the Nakaibito station on May 30, washed out more than 25 per cent of the small dams, but none have been washed out since. At any rate such washouts are not necessarily an indication of inefficiency if the obstructions are cheap enough.

Construction engineers, plant ecologists, and botanists, and meteorologists have been freely employed, but for the labor, Navajo have been employed exclusively. As the Navajo is unaccustomed to steady labor on schedule, and is unskilled in the type of construction so freely employed, some of the work has been inefficient both from the standpoint of amount and quality. In the beginning much rather aimless work was done just because the orders were to put the Indians upon the pay roll at once.

The total area of the experimental and demonstration projects is less than 200 square miles, which is hardly four-fifths of one per cent of the whole Navajo country. The intention is that these areas shall serve to demonstrate to the Navajo what can be done to check erosion and how, so that they will proceed to put these methods into practice throughout their reservation. The success of the undertaking therefore depends upon the Navajo, for the areas covered by the demonstration projects are trifling. In general the Navajo thinks only in terms of the present. Yet most of the headmen have caught the conservation idea and have pledged their coöperation. Such pledges are easy to make under the stimulus of substantial pay rolls; nevertheless they doubtless are based on good intentions.

In view of the size of the total area to be treated and the limited resources of the Indians upon whom the eventual success of the project will depend, such means must be found, presumably on the experimental area, and carried out on the demonstration areas, as have wide application with a minimum expenditure of labor and material. Such is the policy of the present administration at Nakaibito Experiment Station until lately under the direction of E. Musgrave. Any

system introduced must be self-operating and self-sustaining, for anything which requires attention is of little avail with the Navajo. Yet they are beginning to act some on suggestion.

UTILIZATION OF VEGETATION COVER

The protection and reseeding of suitable native plants and the introduction of others promise excellent results. Due to overgrazing in the Navajo country, the more palatable grasses have been replaced to some extent by the more hardy but less desirable species of plants. The best plants grow weaker from season to season as the result of the roots being trampled out and because they are grazed before the seeds have had a chance to mature. Seeding and planting of native species, although expensive, is generally worth while in badly eroded and depleted areas. The saltbushes may be used to advantage on saline or alkaline soils. They give variety to the forage and act as an over story for soil protection. Sage brush may be used on other soils to protect the soil, but it is low in forage value. However the blue grama grass produces heavy stands in the sage brush.

The Russian thistle is an illustration of an introduced plant which has altered the landscape of the Navajo country, as well as other semi-arid areas of the West. The plant was unwittingly brought into these parts, with hay it is believed, about seventeen years ago. By some authorities it has been reported as a pest because of its rapid spread and its slightly barbed brittle stems when mature. On the whole the plant is a benefit to the country. It is frequently the most abundant plant on saline and slightly alkaline soils, but is easily crowded out by other plants. It is found mostly on soils where scarcely anything else would grow, so with its dark green color it makes such areas more pleasing to the eye. It is commonly the first plant to take hold on disturbed surfaces, hence is not a very good soil binder. While young it has considerable value, and in droughts of early summer may be the only plant abundantly available. In midsummer it becomes hard and brittle and blows away as tumble weed to accumulate around clumps of shrubbery and to lodge in gullies. In dry years it is a great help in checking erosion as the dead stalks accumulate in the heads of young gullies

FIGURE 12.—Navajo Indians at work on check dams in the Ganado Demonstration area. Summer of 1934.

and become traps for sand and silt. Due to the short season of the thistle's growth, it affords no surface cover during a large part of the year.

Cottonwoods and willows, easily propagated, may be planted to good advantage in wash bottoms. From the cottonwoods planted at Chinlee, the seeds have been carried down the wash and the trees are scattered for many miles below. Formerly cottonwoods were more common along the washes. In years of severe drought the boughs had to be cut for forage. The tamarisk, introduced from Asiatic deserts, is transforming erosion and sedimentation processes along streams in the lower deserts and the Southwest and is being planted in a few places in the lower parts of the reservation. But it does not thrive in the higher areas with their more severe climate.

The timber margins of juniper and piñon have retreated considerably on the reservation because of the Indians' quest for fuel. Around the Hopi villages the valleys are denuded of wood and even the stems of the shadscale (Atroplex) are used for fuel. The Nakaibito Experiment Station is located in the juniper zone but only a few stunted specimens are found around it now. Cottonwoods once grew along the wash, then a stream, for some miles below the station, as is attested by old stumps and the memory of old Indians. One old one, and only one, is still growing below the station.

Cottonwood and segi willow, a low gray native willow of the Segi Mesa country, are being planted in the main wash at Nakaibito and are proving very effective in holding silt. The segi willow has a ramifying root system from which shoots grow and spread rapidly. It is thus hoped to restore the pristine condition of the valley, now nearly barren and gashed by a dry wash, to one of wooded or grassy slopes with a clear stream flowing through groves of trees.

On the lower open areas several low wide dams have been put in and the water spread upon the land at a cost of about $2.50 per acre; as the areas above the dams fill with silt, they will be planted to trees such as honey locust, which produces a seed for forage, ash, cottonwood, and Chinese elm. Eventually these areas can be cropped for wood. Effectiveness of the efforts at Nakaibito is indicated by the fact that during the past year, a rainy year, the run-off from the area was about 2,000 acre feet, whereas in the year before, a dry year, it was more than 4,000 acre feet. It is hoped that it will be reduced to zero this year.

RODENT CONTROL

Because of the low water content of the soil, the plants in general have very low vitality. Hence insects and rodents, ordinarily not important, become injurious and may cause death to the plants. Rusts also are killing the junipers.

Prairie dogs are the most numerous and destructive rodents on the range. One prairie dog will eat two times its own weight in a week. They eat the tops of the grass, then dig up the roots when the tops are gone. Around their villages they not only eat the forage but cut it off clean to give better vision. They will forage a radius of about one-fourth of a mile, using emergency holes. Estimates of the increase of erosion due to prairie dogs vary from 15 to 40 per cent. In general the Navajo coöperate with the Biological Survey in the work of eradicating prairie dogs, but some Indians are opposed to it because they use them for food.

The Navajo's corn field must run the hazards, not only of climate but also of prairie dogs, rats, and ravens. Strange devices are placed in the fields to scare them away; during the night they use

burning cedar bark which has been rubbed in the hands to make it inflammable.

REDUCTION OF NAVAJO FLOCKS

It follows as a matter of course that if the ills of Navajo land are largely the results of overgrazing, the Navajo flocks must be reduced if any real progress is to be made in restoring the land.

Dipping records for 1936 show a total of 1,080,706 sheep units. All stock is here included, each cow rating as four sheep units and each horse as five. The above sheep units thus included 459,285 grown sheep, 381,016 lambs, 122,847 goats, 17,887 cattle, and 29,162 horses. Range surveys show that the carrying capacity of the Reservation is between 550,000 and 600,000 sheep units. Stocking in excess of that figure will further deplete the vegetation and increase the losses due to erosion. The number of sheep and goats on the Reservation reached an all time peak in 1931 with 976,669 sheep and 345,242 goats. The reduction since then has amounted to 24.2 per cent of sheep and 68.8 per cent of goats.

Sheep and goats have been the life of the Navajo people. Anything that affects their sheep affects their life. They live with their sheep, are attached to them, and if there are not too many, they know them by name. Furthermore, the Navajo have been accustomed to think only of immediate wants and the idea of conservation is to them a new one. It is not strange then that the stock reduction program of the government is the one proposal which has met with considerable resistance.

The number of sheep per family has averaged about four or five hundred. Some of the poorer families do not have over 50 sheep and a few have as many as 2,000. The richest man in the vicinity of Ganado, still living in a primitive hogan, owns 3,000. A Navajo family numbering not more than seven needs at least 150 sheep for bare existence, if dependent upon the product of the sheep alone. An average family numbers about eleven persons and has an income of about $400.

Goats were once recommended to the Navajo. It now seems inconsistent to them that they should be asked to eliminate them in particular. The goats are of course especially bad for the range, but the Navajo learned to prefer them for meat because they remain fatter. They can sell the mohair for as high a price as the wool from sheep. Furthermore the goats are more intelligent and tractable than the sheep, and mixed with the sheep make them easier to manage. Reduction of stock has been carried on through purchases by the drought relief administration. The Indians have been paid from $1.00 to $3.00 for sheep and from $1.00 to $2.50 for goats, which is more than they would have received for the same classes in the open market. In addition to sheep and goats, the Indians still have many useless horses and ponies, although inroads have been made upon them for some time by government purchase and disposal. The Indians in some sections have been reluctant to dispose of them at the government prices of $2.00 to $2.50, preferring to use them for food.

COÖPERATIVE, PROTECTIVE, AND HIGHWAY PROJECTS

The demonstration areas are under fence with five-year coöperative agreements which give the government control of range management and stocking areas. Following a range rest period with the exclusion of all stock, the areas are restocked with Navajo owned sheep under government management. The Ganado area has been the first to be restocked. This year a 93 per cent lamb

FIGURE 13.—Silt catchment in rocky arroyo at the second Mesa of the Hopi Indian villages. Illustrates the painstaking efforts of the Hopi in the way of agricultural land utilization.

crop has been produced from it as compared with 60 per cent in the vicinity outside the area. The average weight of lambs this fall was 69 pounds as compared with 45 to 50 pounds outside the area, while ewes sheared twice as much wool. Range improvement has kept apace.

IMPROVEMENT OF NAVAJO STOCK

It is obvious that if the Navajo must reduce his flocks by about half, there must be some way made possible whereby he can keep his low standard of living at least at par. Will this be possible?

First, there is much room for improvement of the Navajo stock. The so called "Navajo Sheep" has long hair like wool which is well adapted to the hand spinning in their rugs and blankets, but yields a very poor fleece for commercial purposes. Their wool contains very little grease, and is easily washed by the Indian method, using yucca "soapweed" and cold water, instead of soap and warm water. Very little is known of the origin of the Navajo sheep, though evidently they are an evolution, without selection, from sheep in the first place obtained in raids upon Mexican and Pueblo Indian flocks. The sale of rugs several years ago amounted to $750,000 a year. Hence a wool suitable for hand weaving is of prime importance. The Indian Bureau has introduced Merino strains into the Navajo flocks because of the known high market value of the wool and the hardiness of the sheep. The Merino strain has not proved very satisfactory however, because the wool is a very short staple with a very sharp even crimp. This makes it desirable for machine weaving, but the spun yarn will not wash white by the Indian method. The grease catches quantities of dust and dirt making the wool unsuited to the desert environment.

The problem of improvement of Navajo stock is then to find a breed of sheep which has ability to get a living under adverse desert conditions, with a fine quality of wool, as long as possible, loose, not too highly crimped, and free from grease. In a word it should be suited to the Indian blanket weave, yet the surplus wool should be highly saleable. The stocky mutton type should also be striven for.

It has been suggested that since cattle are not so hard on the land as sheep it might be well to encourage the Navajo to shift from a sheep and wool economy to one of cattle grazing. Yet if we may judge by the conditions of southwestern tribes engaged chiefly in sheep breeding and those engaged in cattle raising, the sheep and wool industry has a far more wholesome effect upon the Indian. Sheep keep him continuously busily occupied, while cattle leave him idle for a large part of the year with income poorly distributed encouraging attendant vices and demoralization. So while cattle may be urged for the good of the land, the sheep must remain for the good of the Indian.

RECOURSE TO FARMING

The agricultural resources of the Navajo Reservation are far from exhausted. Irrigation has long been practised in a small way where streams

emerge from the Chuska Mountains and more recently where the Indian service has improved the water supply, as along the Paso Calorado Wash below Ganado, and in the Chinlee Valley. Small patches also are scattered over the reservation on which flood waters can be utilized. Here the Navajo crudely follow the mehods of the Hopi. In general the Navajo is a poor farmer, for he dislikes the painstaking labor which the Pueblo Indians expend on no better land. Several thousands of Hopi succeed in making an independent living on less than 1,000 square miles of land no better than much of the surrounding Navajo Reservation. Hence if the Navajo could be brought to the Hopi methods and economy, their population problem might be solved—for some time at least. Furthermore, if the Navajo can be induced to extend the practices demonstrated on limited areas by the Navajo Erosion Control Project, the tillable areas may be greatly extended. At Nakaibito several hundred acres already have been made available for corn on the lower open flats as the result of spreading water from washes.

The Indians have developed the best drought resisting corn in existence. Twelve-inch ears commonly grow on 30-inch stalks, and often several ears to the stalk. On flood irrigated areas the yield may be as high as 20 bushels to the acre, or on ditch irrigated fields as high as 40 bushels (Figure 14). Fruit production should be encouraged also though it can be grown only locally. In Canyon de Chelly peach trees are growing on roots known to be 64 years old. Peaches are an important crop with the Hopi, but they have not been planted by the Navajo except in Canyon de Chelly. The use of vegetables also needs to be encouraged.

The Navajo is a good politician. So say those who are his neighbors. Hence he is successful in receiving more attention and more benefits from the government than his proverbially stubborn Hopi neighbor, or other Indian tribes in general. He is noted as crafty in trade, and his art is not lost in his deals with Uncle Sam.

FIGURE 14.—Productive Navajo fields in the Tunitcha Mountains, upper end of the Nakaibito experimental area.

REMUNERATIVE EMPLOYMENT

According to the statement of the Commissioner of Indian Affairs, in the summer of 1934, twice as much was being spent by the government per capita for Navajo relief as for white relief. Employment was provided under the Indian Emergency Conservation Work. By the summer of 1935 the number of Navajo employed had been reduced to less than 1,500. The general wage paid by the government was $44.00 per month or $2.40 by the day for ordinary labor; some are paid higher. Others of the Navajo work for the Americans at good wages.

As income increases the standard of living goes up. Most Indians spend their earnings as they are received. Few save anything for the future except as they may invest in jewelry. Unfortunately most of those on pay roll are near towns which exploit the weaknesses of the Indian. Gallup, New Mexico, is surrounded by Navajo domain. Put upon the pay roll the average Navajo

begins with a first payment on a second-hand car and thenceforth becomes a slave to further installments and repair bills, and usually goes into debt. It is estimated that it will require at least three generations for them to learn the lessons of economy.

When the men began to receive wages, the women ceased to weave as many blankets, and they became more scarce. Formerly the man tightened his belt until the squaw had finished her blanket, but with her man on the pay roll the squaw waits for him to bring home the groceries. With decreased employment more blankets are again appearing on the market. Furthermore, under the encouragement of the Indian Service and schools and traders, the blankets are improving in quality. In a way outside employment helps to improve the quality of the blanket product, for when times are good only the more skilled weavers work, but when times are bad, everybody who can, whether skilled or not, must needs weave.

Navajo weaving is a marginal industry which requires favorable circumstances to assure profitable activity. The economic returns are very low at present prices. At the Ship Rock Trading Co. a weaver was recently employed and observed as an experiment, and it was demonstrated that the weaver habitually weaves rugs for a market wage of five cents an hour. With exposure to the luxuries and conveniences of American life, how long may the Navajo women be expected to toil at the loom for a wage of five cents an hour? And when the government subsidized employment ceases, must the Navajo needs go back to the old life deprived of the luxuries for which he has cultivated a craving, to add another discontented element to our population?

EXTERNAL RELATIONS OF THE TYNESIDE GLASS INDUSTRY

Preston Pilbin

THE date of the establishment of a permanent glass industry on the River Tyne, England, is uncertain. The earliest record of glass-making in the district was in A.D. 674, when Benedict Biscop brought workmen from Italy to make the glass windows for Wearmouth Monastery. These men are supposed to have taught the natives their craft, but there is no record of its survival.

Local historians are at variance as to the date of its reëstablishment. Some think that it was recommenced in the time of Queen Elizabeth, while others deny that there was any glass-making on the Tyne until after 1615. This question is still undecided and is not of great importance. It is certain that in 1611 Sir Robert Mansell and others received a monopoly for the manufacture of glass in England, and afterwards set up their works at Newcastle-upon-Tyne.

Early Glass Making in England

Glass had been made in England for centuries before this time, wood being the fuel used. The chief center of the industry was Chiddingfold on the border of Surrey and Sussex, where abundant wood could be obtained from the neighboring forest of the Weald. The output of glass was quite small, and most of it was used in London. The early glass makers were responsible for great destruction of timber. One of them, Giacomo Verzelini, is reported to have consumed 400,000 billets, or about 2,000 wagonloads, in a year. Timber had been used for so long for almost every conceivable purpose, but especially for fuel, that by the seventeenth century there was a serious shortage, which grew more acute as time passed. The position was especially serious round the towns, where the shortage and increasing price of firewood caused growing indignation against reckless users such as glass makers and iron manufacturers. In Warwickshire the people rose and expelled the glass makers by force.

Change to Coal

Elsewhere coal was coming into use as a domestic fuel. It had been used in London since the fourteenth century, but was found to be very smoky and objectionable compared with wood, though no doubt this was mainly the result of bad methods of burning. The fumes of sulphur dioxide produced from pyrites in the coal were most obnoxious, and made the use of coal in glass manufacture impossible, as they spoiled the glass in the pots. The simple solution of using closed pots was discovered by Thomas Percival, who was afterwards a partner in the monopoly. The timber shortage had grown so serious that King James I interested himself in the experiments.

A writer of 1612 says:

> Very lately, by a wind furnace, green glass is made as well by pit-coale at Winchester House in Southwark as it is done in other places with much wast and consuming of infinite stores of billets and other fuell.

The success of the new process was a great relief to the government, which was extremely concerned about the timber shortage. A rapid change from wood to coal took place in the glass industry, and the use of wood was pro-

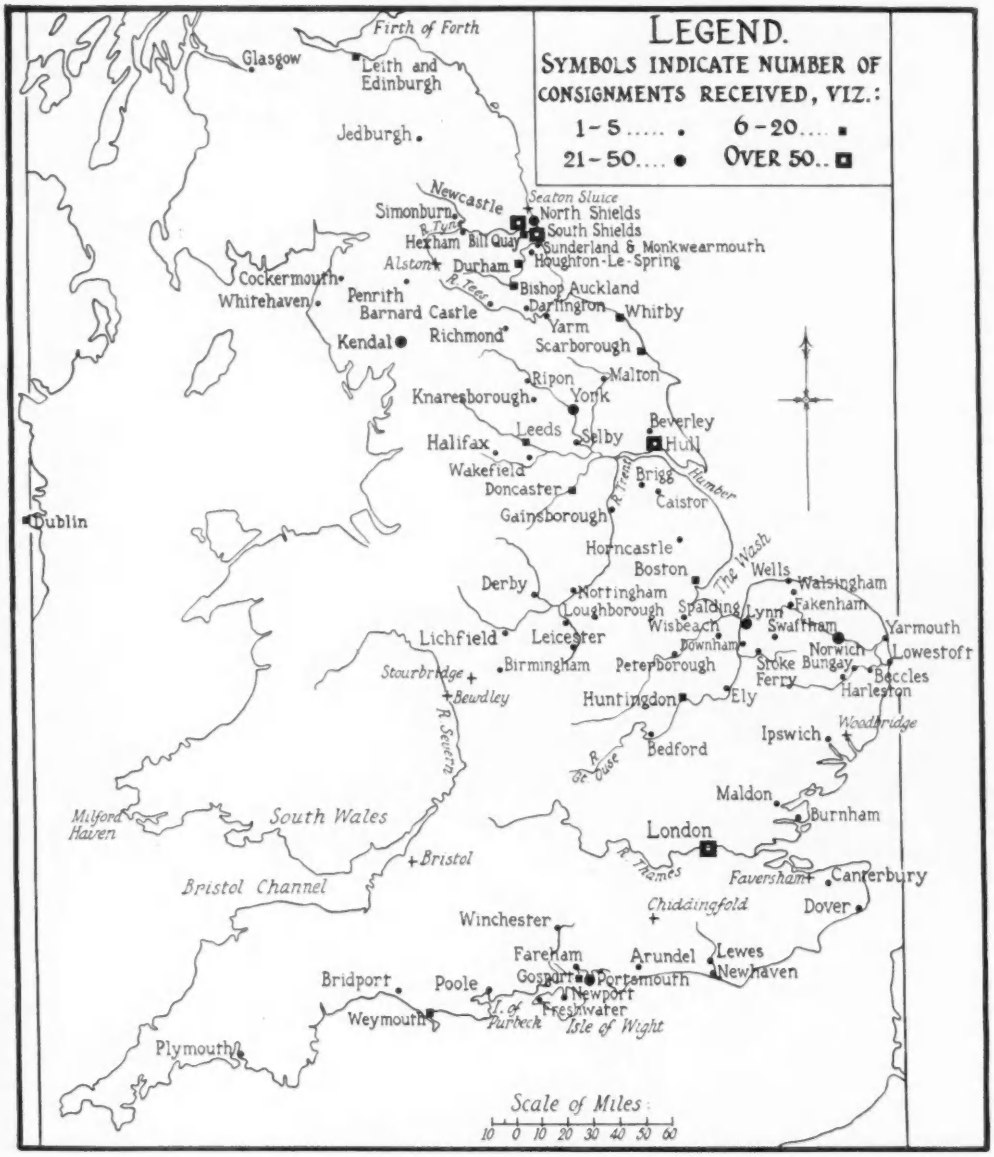

FIGURE 1.—Key map, illustrating the Tyneside glass trade. The symbols indicating number of consignments of glass received show only the trade of Cookson & Jeffreys, South Shields, December 1744 to February 1748. (Compiled and published by permission of Messrs. Cookson & Co., Newcastle-on-Tyne.)

hibited by the "Proclamation touching Glasses" in 1615.

The change of fuel caused far-reaching changes in the industry. Hitherto glass making had been a forest industry. By 1620 it is probable that all the old forest glassworks, particularly those in the Chiddingfold district, had been closed by the ban on the use of wood, and new works had taken their place. These new works had to be situated where plenty of good coal was available.

The first successful experiments had been made with Scottish "great-coal" from the coal fields round the Firth of Forth, a coal of great purity, almost free

from pyrites, but very expensive in London because of the great distance it had to be conveyed. Newcastle coal was much cheaper, as the distance by sea was much less and the trade with London was very well established. Indeed most of the coal used in London was Newcastle coal. Unfortunately it was very "sulphurous" and could not be used in glass making at first. Thus Mansell did not try Newcastle at once. His first works were in London, which had the great advantage of being the only large glass consuming center in the country, and was certainly the chief market for glass. Unfortunately all the materials required in glass making had to be brought from a distance.

FIGURES 2 AND 3.—The burning of seaweed formerly provided an important source of alkali for the glassworks. These photographs, taken recently on the north coast of Ireland, show that kelp-burning is still carried on, though the principal product now is iodine.

GLASS MAKING MATERIALS

It is convenient at this stage to consider exactly what materials are, or were, required in glass making. Fuel has been discussed already.

All glass at this early time was made in clay pots and refractory clay for making the pots was an important requirement. There are many satisfactory fire clays in various parts of England, but few good pot clays. The only one which has achieved fame by its uniformly good quality is the Stourbridge clay. This is one of the reasons for the existence of a glass industry at Stourbridge, and fairly good communications with that place were essential for any glass making center. The Stourbridge clay is believed to have been worked since 1556.

Then there are the actual ingredients of the glass, or "batch" materials. Of these the most bulky is sand. Special kinds of sand are necessary in glass making. A uniform grain is best, and it must be free from dust and clay, as these cause bubbles in the glass. Above all it must not have more than a very small percentage of iron, as this gives the glass a green, yellow, or brown tinge, and spoils its luster. Very few sands are pure enough for good glass, but a large number are satisfactory for dark bottles and coarse window glass. Requirements of sand therefore placed further restrictions on the locations of the glass industry. Sand for the best glass has generally been imported. That made by the crushing of the white Fontainebleau sandstone near Paris is the most favored.

Another essential constituent is "alkali," which might be either soda or potash, and was in fact often a mixture of both. The kind used in the early days depended entirely on the local resources. In forested areas the alkali used was generally potash, produced from the ashes of wood, grass, bracken, and other vegetable matter. On the coasts the chief source was the kelp pro-

duced by burning seaweeds, which gave a crude alkali consisting mainly of soda. Another method of obtaining alkali was by the use of alum, which was produced in England only from the Alum Shale of the Jurassic system. It was also imported from the Papal States, which were the chief European producers. A little crude alum for dyeing was made in the Isle of Wight in the Middle Ages, but the industry only began on a commercial scale in Elizabethan times when the shale was rediscovered in the Isle of Purbeck in 1560. The Alum Shale was also discovered in north Yorkshire a little later, and was worked both in the interior and on the coast. Yorkshire had a great advantage over Dorset in being near a coal field.

Lime is a valuable constituent of glass, but is not essential. Magnesia and red lead became important later, but were not used at first.

EXPERIMENTAL SITES

Mansell had therefore to find the best place in England for the assembly of coal, pot clay, sand, and alkali, and for the distribution of the finished product to London and elsewhere.

After London he tried the Isle of Purbeck (Figure 1), where alum was made and where good sand was easily obtainable from the Isle of Wight and the New Forest. Unfortunately there was no coal, and both coal and pot clay had to be carried a great distance. Further, the glass, when produced, had to be carried to London, which added to its cost.

Milford Haven in Wales was tried; there he had access to excellent coal, and some of the sand along the shores of Bristol Channel was good enough for the coarser kinds of glass. He may have had some local pot clay, but if the best pot clay were required there would be substantial transport charges from Stourbridge. In addition the distance to London for the finished product was very great.

Mansell next experimented at a place on the Trent in Nottinghamshire, where he had access to some very good coal, and it might have been possible to convey Stourbridge clay across country by pack horse and boat; but here again he was too far from his chief market and from some of his chief raw materials. So, as he himself said:

> For his last refuge he was enforced to make triall at Newcastle upon Tyne, where after the expence of many thousand pounds, that warke for window glasse was affected with Newcastle cole.

No doubt the difficulties associated with the "sulphurous" coal had been overcome by some small technical improvement. At first only coarse window glass could be made at Newcastle, but before 1624 it had been found possible to make white glass, crystal glass, and all other kinds of glass, with common "seacole."

Newcastle and Tyneside had thus been chosen as the seat of glassworks which were to supply all England. This does not mean that all other glassworks were suppressed, though probably most of them were. A few works remained in operation, presumably under the license of the monopolist, at Stourbridge and perhaps elsewhere.

ADVANTAGES OF NEWCASTLE

The suitability of the Newcastle district as the headquarters of the British glass industry may be summed up in the two words: *coal* and *transport*.

Coal was to be had in abundance. It had been worked round about Newcastle on both sides of the Tyne for several centuries. The higher seams were apparently of poor quality, but by the time of James I the deeper and better seams were being worked. During that and the preceding reign, a change

came over English industrial life which deserves to rank as an industrial revolution, and the production and export of coal increased rapidly. Thousands of carts were used to bring the coal down from the pits to the riverside, where it was shipped off to the East Coast ports, most notably to London, where the Thames, even at that time, was often crowded with Tyne colliers. Indeed, nearly all the coal used in London came by sea from the Tyne or the Wear, as no other coal field on the East Coast of England had easy access to the sea, while the Firth of Forth and South Wales fields were too distant to compete successfully. The Tyne coal trade was thus very well organized and provided perhaps the most frequent and regular sailings between any two ports in the world at that time. Still, the cost of transport was very heavy, and coal usually cost nearly four times as much in London as in Newcastle. The supply was also likely to be interrupted by bad weather, or by war or pirates, and London prices usually became very high towards the end of winter. There was thus a great saving in cost by having the glassworks at Newcastle rather than in London.

The coal trade also proved a great convenience in transporting the glass to London fairly cheaply and conveniently. A writer in 1703, after describing the packing of glass in cases for transport, continued:

> These cases are brought to London in the coal ships, they being set on end in the Coles more than half its depth, by which means they are kept steady from falling and being broke by the motion and rowling of the ship. Mr. Leybourn saith, the price of glass is uncertain, for when coals are plenty then glass is cheap, and when coals are dear at London, then glass is so likewise, not that they want coals at Newcastle, but because they have no other conveyance for it to London. So that sometimes it is 30s. per case, and other times 40s.

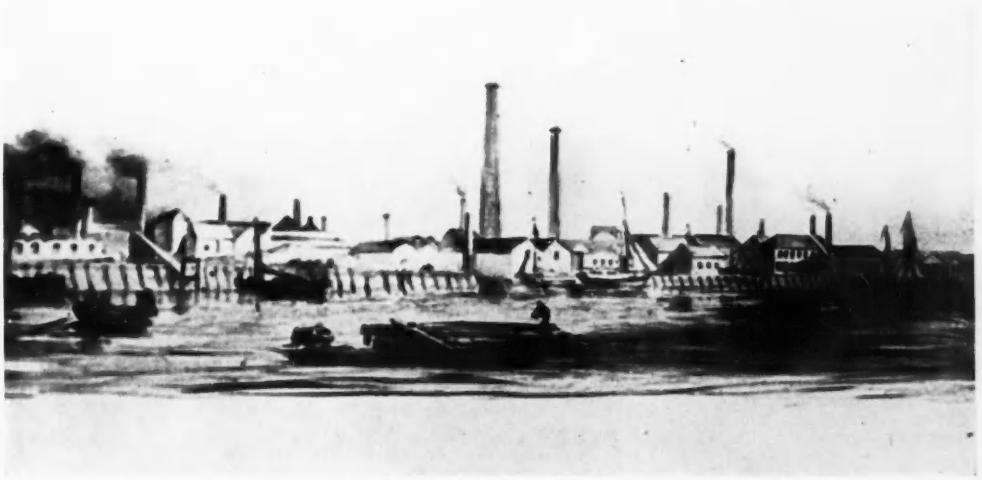

FIGURE 4.—Jarrow chemical works (from an old painting in South Shields Public Library). The chemical industry on the Tyne began in order to supply the glassworks with "alkali." These works (demolished in 1891) evolved from Cookson's original "Alum House," founded about 1700. (Courtesy of the Public Librarian, South Shields.)

As for *pot clay*, the Tyneside glass makers were largely dependent on Stourbridge, and the cost of transport must have been high. Mansell himself, in one of his letters, said that pot clay "cannot be got nearer than the county of Stafford." There is no information as to the transport of clay as early as this, but a century later the trade

was well developed. The clay was worked in a manner similar to coal mining, was dried and powdered, and carried in sacks by pack horses to Bewdley, whence it was sent down the Severn by boat to Bristol. From Bristol some of the clay went on to London by sea, as the Thames and Severn Canal was not opened until 1792. (There is a letter complaining that 20 hogsheads of Stourbridge fireclay delivered in London had been damaged by sea water.) The final stage of the journey to the Tyne was easy and cheap; the coal ships had great difficulty in obtaining return cargoes and offered very cheap rates; so we hear of "Bristol and Stourbridge clay" being brought to Newcastle "for a trifle as ballast of ships." This seems a very long and circuitous route, but apart from the carriage to Bewdley it was all by water, and was much cheaper than the long overland route.

Although Tyneside was always dependent on Stourbridge pot clay it was not entirely devoid of resources nearer at hand. The local fireclays were not satisfactory for glass house pots, but a good pot clay was discovered at Felton, in the middle of Northumberland, about 25 miles from Newcastle. It was first worked in 1624, soon after the industry had been established. It was sold by the tenant to the glass makers at 20s. a ton. A few figures of output have been preserved; they are as follows:

	Tons
1695	106
1762	188
1763	283

This clay was used extensively on the Tyne until 1772, when the lease of the clay pit was given up. It seems that the facilities for conveying Stourbridge clay had improved to such an extent that it was actually delivered on the Tyne more cheaply than the Felton clay. Thus, while there was a local source of pot clay it cannot be regarded as one of the localizing factors in the industry.

The local deposits of *sand* do not seem to have been of much value, and certainly have not been used recently. The shore sand on the Northumberland coast was used at Seaton Sluice for making bottles and coarse window glass, but for most purposes sand was imported. One interesting point may be noticed—the use of the sandy mud of Jarrow Slake (an expanse of tidal flats on the south side of the Tyne) for the manufacture of glass bottles. This mud is a strange mixture and contains all the materials essential for glass making, besides much that is unnecessary and even harmful. It was used for some time, but was abandoned when better materials became available.

The most accessible deposits of really good sand in England were at King's Lynn, which was a port of some consequence before the great increase in the size of ships. A note of 1844 says:

> A fine species of white sand much used in the manufacture of glass is sent in large quantities to Newcastle and Leith.

Sands for the best kinds of glass had, however, to be imported, and here again the coal trade was an invaluable help to the glass industry. The chief sources were the Fontainebleau sand from the Seine and another very good sand from Moll, 30 miles east of Antwerp, to which port it was easily conveyed by canal. Both of these sands were brought to the Tyne in large quantities as ballast in the colliers returning from the Continent, at a very cheap rate. The Tyneside glassworks were therefore able to use the best sand in types of glass for which an inferior sand would have been satisfactory.

The question of the supply of *alkali* for the glassworks is very interesting. As the great forest which originally covered most of the district had been

greatly diminished by its use for fuel and for mining timber, the early source of soda was the seaweed of the coast. Kelp-burning was an important source of income to the poor people on the coast, although it created so much objectionable smoke that it seems to have been banished to more remote parts of the country. The weed was collected at low tide during the summer, dried in the sun, and burned. A dark-colored alkaline substance was obtained, which was sold to the glass makers, who prepared "crude alkali" for their own use. It was also used in the manufacture of soap. Kelp-burning seems to have ceased on the Northeast Coast by the end of the eighteenth century.

A purer kind of alkali was made from the alum produced in Yorkshire. The alum industry there began soon after 1600, that is, about the same time as glass making on the Tyne. The process of preparation was complicated, and involved the burning of the alum shale and afterwards the evaporation of the solution obtained by dissolving the residue in water. It was thus very extravagant with fuel, and large quantities of Durham coal had to be carried to the alum works to supplement the local brushwood. An improvement was effected by concentrating the works on the coast, which saved the cost of transport, and later by carrying out part of the process on the Tyne, where coal was much cheaper. Mr. Cookson, one of the glass makers, had some small vessels fitted with tanks, and brought the "alum liquor" from Yorkshire to the Tyne for evaporation. Among the by-products of the process were Epsom salts, which were at one time produced in large quantities.

At certain periods soda was imported from the Canary Islands and Spain, where it was made from a seaweed known as barilla, which had a very high concentration of soda. Potashes were also imported from Russia. During the Napoleonic Wars these sources were cut off, and the period saw an enormous expansion of kelp-burning round the coasts of Scotland and Ireland, which became the chief source of soda for all purposes.

By this time successful experiments were being carried out in the production of soda from salt. These were hampered by the preposterous salt duty of £36 a ton, but some of the manufacturers secured exemption from this duty until its abolition in 1823. The first experimenter to achieve any great success in the district was Mr. Losh, at Walker-on-Tyne, about 1797. He obtained salt by the evaporation of a brine-spring discovered in Walker Colliery, and managed to produce a considerable range of sodium compounds sufficiently pure to be used in the glassworks. Two advertisements in Newcastle papers in 1797 record the successful use of Mr. Losh's products.

Twenty years later, the Leblanc process of soda manufacture was introduced on the Tyne, and there was no further anxiety over the supplies of soda.

Red lead was used extensively as a constituent of flint glass. It was a local product. Lead had been worked in the northern Pennines for many centuries, and the chief refining mills were on the Tyne. These mills produced large quantities of red lead in the course of their operations, and could, if necessary, refine it sufficiently for use in the glassworks. The conveyance of the pig lead from the mining districts to the Tyne was a difficult matter in the early days. Trains of ponies were used, and some of the tracks they followed can still be traced across the moors. Early in the nineteenth century a system of roads was constructed by Macadam, and

the pack horses were replaced by carts. In the middle of the century a railway was built to Alston, the chief center of the lead mining industry, and the carts were superseded in their turn. The Tyneside lead industry grew to great proportions in the nineteenth century, though it depended partly on imported ore. Very little lead is now mined in the Alston district.

LOCAL CONDITIONS

The local conditions affecting the development of the Tyneside glass industry have been dealt with in my article published in 1936 in the *Journal of the Tyneside Geographical Society*. Here it is sufficient to say that Sir Robert Mansell's works at the east end of Newcastle were followed by others at several places on both the north and south sides of the Tyne, wherever there was a patch of reasonably level land adjacent to a deep-water channel. Water transport was a prime necessity to all these works, since they were hemmed in behind by the steep sides of the valley, and the river formed their only means of communication. The most common river craft was the Tyne "keel," a stoutly-built lighter managed by three men and a boy, and propelled by either oars or sails as opportunity offered. These linked up the various glassworks with their coal supplies and with the ships which brought in sand, clay, and other materials and took away the glass produced. The close relationship between the glass and coal trades has already been noticed.

TRADE IN GLASS

The glass industry on the Tyne flourished for over two centuries, and the combined output of the numerous works was very large. The following statement gives the numbers of glass-houses in the principal districts of England and Wales about the end of the seventeenth century:

London	24
Stourbridge	17
Tyneside	11
Bristol	9
Other coal districts	29
Total	90

From the very beginning the Tyne depended mainly upon coastwise shipment for the marketing of its glass products. As early as the time of Mansell the bulk of the produce was "shipped off in cases to other ports," and "2,706 cases were shipped in the year 1655. This glass was sold in London at 16s. per case."

This practice was followed by Mansell's successors, several of whom are known to have had agents in London. The activities of these agents can be traced by their advertisements in the London newspapers. Mr. Francis Buckley has found examples as early as 1691. It appears that for a period expiring in 1709 there was a regular agreement between the Newcastle glass makers and the London glaziers for the supply of window glass. An account of the method of conveying the glass to London has already been given (p. 305).

The firm of Cookson & Jeffreys, glassmakers, South Shields, maintained a permanent warehouse in London, and Mr. Jeffreys, one of the partners, resided there. Two advertisements quoted by Mr. Buckley throw some light on his activities:

London Evening Post, 17 January 1740:

From the new glass house lately erected by Cookson and Jeffreys at South Shields, near Newcastle, the best Crown Glass is to be sold at their warehouses near the Old Swan, near London Bridge.

General Advertiser, 16 July 1740:

Removed since Mid Summer Day, from the Old Swan to the Great House at Black Fryar's Stairs: where daily attendance is given for the sale of Crown Glass made by Cookson and Jeffreys from their newly erected works at South

Shields. N.B. Glaziers and Dealers in Glass who live in or near Seaport Towns that trade with Newcastle are desired to send their orders to John Cookson, Merchant, in Newcastle.

An old Day Book belonging to this firm has fortunately been preserved, and the present writer has been able to examine it through the courtesy of Messrs. Cookson & Co. of Newcastle. It covers the period from December 1744 till February 1748, and gives an excellent idea of the trade of one of the most enterprising of the Tyneside firms, as well as much information about general trading conditions at the time.

Sales can be divided into two groups: those consigned to "Thos. Jeffreys, Esq., Snow Hill, London," and those sold from the South Shields works. During the period covered by the Day Book 86 out of a total of 844 recorded consignments went to Jeffreys. This does not give a correct impression of the trade done through the London warehouse; the London consignments were all very large, and a rough estimate gives their aggregate value as about one-and-a-half times that of all the rest, that is, about 60% of the total trade was done through the London warehouse. In addition, 10 other consignments were sent direct to dealers in London.

Advertisements show that some of the other Newcastle glass makers worked in the same way, and they also suggest that it was a common practice for captains of ships to buy quantities of Newcastle glass in London for shipment abroad.

Although the London connection was of the first importance, that was not the only place with which Tyneside glass makers had permanent trading connections. Advertisements quoted by Buckley from provincial newspapers indicate the existence of agents for Newcastle glass and bottles in several towns, including Leeds, Norwich, Faversham, and Exeter. The Faversham agent also offered coals, coke, and grindstones—all typical Newcastle products.

FIGURE 5.—Langley lead mills. Lead ore from the Pennines was carried by trains of packhorses to these old mills to be smelted. Much of it must have been used in the Tyneside glassworks. (Courtesy of Miss Muriel Lishman.)

The old Day Book of Cookson & Jeffreys illustrates this aspect of the glass trade very well. Their trade showed extensive ramifications both in England and abroad. This trade has been reconstructed, with very interesting results. The destinations of all consignments have been plotted on a map, the symbols used giving a rough indication of the magnitude of the trade with each place.

Examination of the Day Book confirms Nef's statement that the bulk of the trade was carried by sea, and the distribution map shows the influence of this mode of transport very clearly. Only glass destined for the interior of Durham and Northumberland and for the northwestern counties was sent by land transport; and, significantly enough, the only mention of a serious breakage concerns a consignment for Durham, when 40 squares were smashed. Goods for Newcastle and other places on the Tyne were sent by river, as is shown by the frequent charges for "wherryage." Goods go-

ing farther west were also "wherried" up to Newcastle before being sent off by land.

The whole of eastern and southern England received glass from South Shields, and the distribution makes it almost certain that the glass was conveyed by sea to a convenient port, then by river as far as possible. This is confirmed by a study of the entries in the Day Book. For example, on the 15th May 1745, the *Anvill* left the Tyne with consignments of glass for Hull, Beverley, Malton, and Knaresborough. On a subsequent voyage she sailed for Hull. It is difficult to resist the conclusion that the first cargo was unloaded at Hull and sent by river transport—on the R. Hull to Beverley, and via York to Malton and Knaresborough. On the 28th September of the same year, the *William and Francis* took glass for Lynn, Ely, and Stoke Ferry (Norfolk). Here again, Lynn was the seaport, and Ely and Stoke Ferry could be reached by boat on the Great Ouse and its tributary the Wissey. Glass for Caistor and Brigg (in north Lincolnshire) was sent via Hull in the *Happy Return* (2nd October 1745). Combined shippings for Yarmouth and Norwich were frequent. The *Saltinstall*, which apparently plied from Hull, took goods for Ripon, Nottingham, and Loughborough (29th March 1745). Evidently Nottingham, Loughborough, and Leicester were reached via the Trent and Soar, using Hull as an entrepôt. There is reason to believe that glass for places as far inland as Lichfield and Birmingham went by the Trent route, for the *Freeman*, which had once taken glass for Hull and Doncaster, on the 22nd October 1745 took a consignment for Birmingham, and goods for Lichfield were sent by the *Endeavour* of Gainsborough (22nd April 1745).

The places receiving glass from South Shields thus appear to fall into a number of distant groups, each focusing on a port or group of ports.

DESTINATIONS OF GLASS
Sent out by Cookson & Jeffreys, South Shields
Dec. 1744–Feb. 1748

(The number after the name of each place indicates the number of consignments received, according to the firm's Day Book.)

I. *Tyne Group*—Land transport from Newcastle or South Shields: Newcastle 100, South Shields 59, North Shields 31, Whitley 3, Bill Quay 9, Houghton-le-Spring 2, Durham 10, Bishop Auckland 17, Barnard Castle 1, Hexham 1, Simonburn 1, Penrith 2, Kendal 21, Cockermouth 2, Whitehaven 1, Jedburgh 1.

II. *Sunderland and Monkwearmouth* 5.

III. *Tees Group*—port Yarm: Yarm 2, Darlington 1, Richmond 5.

IV. *Whitby* 6.

V. *Scarborough* 9.

VI. *Humber Groups*—entrepôt—Hull:
   (a) *Hull Group*—Hull 52, Beverley 2, Brigg 1, Caistor 3;
   (b) *Ouse Group*—Selby 2, York 35, Malton 2, Ripon 2, Knaresborough 5, Leeds 9, Wakefield 5, Halifax 3, Doncaster 8;
   (c) *Trent Group*—Gainsborough 3, Nottingham 4, Loughborough 1, Leicester 2, Derby 2, Litchfield 1, Birmingham 2.

VII. *Wash Group*—ports Boston, Lynn: Boston 11, Horncastle 1, Spalding 3, Wisbeach 1, Peterborough 2, Lynn 21, Downham 1, Ely 2, Huntingdon 6, Bedford 3, Stoke Ferry 1, Swaffham 3.

VIII. *Wells Group*—Wells 3, Walsingham 1, Fakenham 2.

IX. *East Anglian Group*—ports Yar-

mouth, Lowestoft: Yarmouth 5, Norwich 47, Lowestoft 4, Beccles 4, Bungay 3, Harleston 2.

X. *Suffolk and Essex Coast*—Ipswich 3, Maldon 1, Burnham 1.

XI. *London*—96 altogether.

XII. *Dover* 1, Canterbury (perhaps via Dover) 2.

XIII. *Newhaven* 1, Lewes 1.

XIV. *Arundel* 2.

XV. *Hampshire Group*—chief port—Portsmouth: Portsmouth 20, Gosport 11, Fareham 3, Winchester 1, Newport 4, Freshwater 1.

XVI. *Poole* 4.

XVII. *Weymouth* 6, Bridport 3.

XVIII. *Plymouth* 4.

The absence of consignments to places immediately around London is the obvious result of the presence of the London warehouse, which supplied the home counties. The only exceptions are the Essex coast ports, but the circumstances there were rather special; many of the coal ships were owned by people resident in those towns, and it was a common practice for the colliers to call there on their way to the Thames. A further instance of this is probably represented by the following advertisement:

Ipswich Journal, 13 July 1771:

Glass bottles will be sold until Michaelmas next at J. Stowe's Bottle Warehose, on the Common Key, Woodbridge.

It is not certain that this notice refers to bottles from the Tyne, but it is known that the Tyneside glass makers obtained broken glass from Woodbridge.

The quantities of glass sent from the Tyne to Scotland and Ireland in the eighteenth century were small, if we can take Cookson & Jeffreys' shipments as typical. A certain amount was sent to the chief Scottish towns—Edinburgh and Leith (6), Glasgow (1), Perth (1),

FIGURE 6.—Lemington Glassworks in 1915. These important works were founded about 1790 and are still flourishing. The huge conical glasshouses shown in the photograph have since been demolished and replaced by modern buildings. (Courtesy of the Lemington Glassworks, Ltd.)

and Aberdeen (2). These presumably went by sea from South Shields or Newcastle. A gentleman living near Jedburgh also ordered some glass from South Shields. A consignment to Kirkwall in the Orkney Islands is rather interesting, as it was despatched in the ship *Providence*, bound for London. Presumably there was no prospect of a direct sailing at the time. Three consignments in all went to Kirkwall.

In Ireland, Dublin appears as the only place receiving South Shields glass regularly. It received fifteen consignments in the period covered by the Day Book, some in response to orders, others as "adventures." Cork was the destination of one consignment in 1745, but this was not followed up. It is not evident from the Day Book whether direct sailings to Dublin were usually available. Most of the goods were certainly sent by sea from the Tyne, but the ships themselves may not have been bound for Dublin. Thus on the 3rd December 1744, glass for Dublin was sent by the *George*, but this ship appears afterwards as sailing regularly between the Tyne and London, and was probably a collier. It is likely, therefore, that it only took the glass to London, whence it was forwarded by another vessel. One entry for Dublin contains the item, "Wherryage to Newcastle, 3d." It is just possible that this consignment may have been sent overland for shipment from a west-coast port; but it is more likely that it was shipped from Newcastle.

All the above notices have referred to bottles or to crown and broad glass, with the occasional addition of plate glass. No reference to flint glass appears, although several of the Tyneside glass-houses were flint glass-houses. It seems that the local flint glass was not good enough to compete with that from London and elsewhere, and was used only in the district. Some of it probably went to Ireland, as Mr. Buckley states that advertisements for Newcastle flint glass appear in some Irish newspapers in the eighteenth century. The same writer states that towards the end of that century the production of fine table glass about Newcastle increased enormously; presumably it had obtained a wider market than it had formerly enjoyed.

A great deal of information concerning the glass trade of the Tyne can be obtained from the Shipping Reports of the Newcastle newspapers. It appears that large quantities of broken glass were brought into the Tyne from 1788 onwards, and probably before that also. A table compiled by Mr. Buckley from notices appearing during one year in the *Newcastle Chronicle* shows a number of ships, presumably colliers returning light, bringing frequent cargoes of broken glass from London, Yarmouth, Bridlington, and Southampton. Similar imports into Sunderland have also been recorded. It may be noticed, incidentally, that cullet and waste glass were often exchanged among the various glass-houses on the Tyne. Thus Roddam, Cookson & Co. of Newcastle frequently bought cullet and "waste metal" from Cookson & Jeffreys.

FOREIGN TRADE

The newspapers are again helpful in the case of foreign trade. A table compiled by Mr. Buckley from the *Newcastle Journal* for the year 1743–44 shows shipments to Guernsey, Rotterdam, Dordrecht, Emden, Hamburg, Stralsund, Danzig, "the Sound," Christiansand, Ostend, Dunkirk, Oporto, Lisbon, Marseilles, and Boston (Mass.). Of these the most frequent shipments were to the Sound (21), Rotterdam (10), and Hamburg (8). This may be compared with the correspond-

ing list obtained from Cookson and Jeffreys' Day Book for the export business of that firm, 1744–48:

Destination	*Number of Cargoes*
Rotterdam	2
Amsterdam	1
Bremen	1
Hamburg	11
Copenhagen	3
Christiansand	1
Bergen	3
Dunkirk	1
Lisbon	1
New England	1
Rhode Island	2
New York	1
Carolina	1

It is probable that some glass was also exported abroad by the various Newcastle merchants who bought glass from Cookson & Jeffreys, but no information is available.

Hutchinson, in his "View of Northumberland," gives the information summarized below. It is supposed to be derived from the return for the purposes of the Excise Act of 1745; "White Glass" is taken to mean Crown, Plate, and Flint glass; "Green Glass" means Broad glass and Bottles:

EXPORTS OF GLASS FROM NEWCASTLE

Destination	*White Glass* cwts.	qrs.	*Green Glass* cwts.	qrs.
Africa	31	2	454	2
Denmark and Norway	75	.	96	3
Germany	298	.	41	3
Gibraltar	...	.	203	1
Guernsey	4	3	248	1
Holland	544	2	4,284	2
Jersey	55	.	213	2
Ireland	1,184	2	418	3
Portugal	...	.	457	3
Russia	58	2	3,002	3
Sweden	20	1	...	.
West Indies	46	.	...	.
	115 tons 18 cwts.		476 tons 12 cwts. 3 qrs.	

These tables show that the foreign trade was not large, even if we include trade with British colonies, and that it consisted mainly of the coarser types of glass especially bottles. The majority of the cargoes were destined for the North Sea and Baltic ports, many of which had well-established relations with the Tyne in the coal and timber trades. Most of the cargoes sent to America were in the nature of "adventures," showing that the trade in that quarter was not well established.

The excise duty on glass, imposed in 1746, caused a serious diminution in production, not only because of the necessary rise in prices, but also because of the restriction placed upon the manufacture. The glass makers addressed frequent petitions to the government, praying for relief from the tax, but it was not removed until 1845. A commission investigated the matter in 1835. When the glass manufacturers were asked to what markets they exported, they replied, "To the East and West Indies and South America," while Mr. Shortridge, of Newcastle, added, "A good deal to the United States and Canada." These answers show a marked change from the exports in 1744–45, when no shipments to South America, the East Indies, or Canada were recorded, and not much to North America. Indeed, as we have seen, the chief export markets in the earlier period were the ports of Northwestern Europe,

FIGURE 7.—Newcastle engraved glass. Although its principal products were window glass and bottles, Tyneside also produced some very fine glassware, as this photograph of a set of engraved glasses shows. (Courtesy of the Curator, Laing Art Gallery and Museum.)

though even then the West Indies were taking a small amount of "white glass." It is possible that the change may be more apparent than real. This can be explained if we suppose that in the eighteenth century Tyneside glass destined for a port not occupied in the coal trade would usually be sent from the London warehouses, not directly from the Tyne, while at a later date shipments were more frequently direct, because of the great development of shipping facilities. On the whole, however, it seems more likely that some substantial change in the trade had occurred, probably as a result of increasing glass production in the continental countries, especially in Belgium and Germany.

The coal trade, the ancient ally of the Tyneside glass trade, to which it was indebted for its cheap import rates and frequent sailings to London and the east coast ports, was not of great assistance in the latter half of the nineteenth century, when the glass trade was faced with foreign competition in the home market. The same considerations which made it easy to import Belgian sand into the Tyne facilitated the conveyance of Belgian glass to London. The freight charges on glass were given in 1889 as:

Antwerp to London (190 miles)	4s.
Newcastle to London (360 miles)	25s.

These charges are not at all in proportion to the distances, and when taken in conjunction with the low standard of living which prevailed in Belgium at that time, they made the competition between Tyneside and Belgian glass makers very severe. This was mentioned in the reports of the British Association for the Advancement of Science, meeting in Newcastle in 1863, and again in 1889.

DECLINE OF TYNESIDE GLASS INDUSTRY

The great decline of the glass industry on Tyneside and at Sunderland and elsewhere in the neighborhood towards the end of the last century is usually attributed to German and Belgian competition, but the change in the conditions had a geographical basis.

After the removal of the glass duties in 1845, the British glass trade entered upon a period of great expansion and easy success. By about 1870 this easy period had passed. The Germans, who had been hampered at first by difficult political conditions, began to compete with British exports and even invaded the home market. Eventually, instead of a large export of glass, Britain had a large net import, and the trade suffered a period of intense depression.

In this depression the Tyne suffered most severely because of its dependence upon special conditions of transport, which were now passing away. The replacement of the old collier brigs by steamers equipped for water-ballast reduced the facilities for the cheap importation of sand. The growth of the inland transport system also had the effect of encouraging the glass making centers in the interior, which had formerly been handicapped by their defective transport, and thus reduced the advantages which Tyneside had previously derived from its sea connections. As a result the largest glass making establishments in South Shields and Sunderland were forced to close in 1891 and 1896 respectively, and have never been revived. The number of active glass-houses in the district now is very small, and most of these are highly specialized.

Thus the Tyneside glass industry rose to a position of great importance because of the successful utilization of geographical advantages, and declined when changes in the technique of transport altered the value of the geographical circumstances. History repeats itself in industry as in all things else.

CULTIVATION AND EXPORT OF NETHERLANDS FRUIT

Aage H. Kampp

DURING recent decades world cultivation of fruit has undergone a great change; economic improvements have created higher standards of living and consequently greater demand for fruit.

Cultivation of fruit as an occupation supplementary to farming, goes back very many years, but not until late years has it succeeded in gaining a place coordinate to other food-producing trades. Cultivated fruit plants are mentioned in records from ancient Greece and Egypt, and it has been proved that fruit was also grown by the lacustral dwellers in middle Europe. In the modern sense of the word, however, the cultivation of fruit is a comparatively new thing in northwest Europe.

In the Netherlands the peasant in early medieval ages fenced a piece of ground for food producing plants; the Dutch word for garden, "tuin" originally meant the hurdle of twigs round the garden. Around monasteries and manor houses decorative plants were chiefly grown, but fruit gardens were likewise of importance. They increased in number in the flourishing period of the Netherlands, especially about the towns, and thence spread to places whence fruit could be carried to the towns by waterways. The Netherlands are particularly adapted to cultivation of fruit for two reasons: the equable marine climate, and the power of regulating the subsoil water level.

At first everything was grown on cold soil, and hotbeds were used to a small extent for grapes and early fruits; but as demand for early fruit increased hothouses were built. From primitive cultivation orcharding became an economically well-organized industry. The old "boomgaard" which produced only second- and third-class fruit, fit for cooking, was now replaced by a more modern form, the "fruittuin," the fruit plantation, aiming at the production of first-class table fruit.

In the "boomgaard" people hardly knew what sort of fruit would result when a tree was planted. Nowadays the variety is definitely known and the quality of the soil and the depth of the subsoil water is carefully examined beforehand; and a sheltering belt, often of pear trees, is planted.

The cultivation of fruit increases from year to year, not least that grown under glass. About 75,000 ha. of Dutch land are used for gardening, and of these more than 35,000 ha. are for fruit. The causes of this increase must be sought in: (1) improved methods of regulating the subsoil water level, (2) the development of communications with foreign countries, especially with England and Germany, (3) an increasing demand from abroad owing to the growth of the towns, (4) better instruction as to growing only the few sorts of fruit for which the demand is greatest, spraying the trees, and better grading and packing of fruit. Yet there seems to be little progress toward improving apples and pears, in spite of the endeavors of the government and the unions. A fifth point, the question of organization, will be mentioned later.

The horticulture of the Netherlands may be divided according to products into: (1) cultivation of vegetables, (2) cultivation of fruit, (3) nurseries, (4) growing of flowers, and (5) growing flower bulbs. The phases are gener-

ally operated separately, and each has its own district or districts.

LOCALITY: DETERMINING FACTORS

The growing of fruit places great demands on the tilth and the moisture of the soil. Besides, the quality of the soil and the level sub-soil water is very important. Almost everywhere in the Netherlands the latter is very high, and regulated through sluices and water works, by which drying out in summer and marshiness in winter are prevented. Most fit for fruit is a deep layer of light clay loam, rich in humus, with a subsoil water level of from 1 to 1.5 m. On good clayey and deep sandy soil orcharding is possible when artificial manures are supplied and the water level is .75 to 1 m. Such soil is, however, mostly used for vegetables and flowers. Boggy soil is generally unsuitable, especially for pears. It is a little more suitable for apples and still better for black currants and raspberries. The soil must be at least .5 m. deep, good loam, and the water level at least .75 m. below the surface. The bogs in the neighborhood of the towns are now to a rather large extent drained and used for orcharding. Loess is very suitable.

On the diluvial areas especially, bush fruits are grown. The rivers have improved the possibilities of the diluvial sand by covering it with a layer of clay. Along the Maas in Limburg the clay belt is very narrow, but below Mook it gets broader. The river clay deposits along the Rhine begin at Bonn as a narrow belt, and broadens toward the boundary of the Netherlands.

The Netherlands are situated in the north temperate zone between 3° 25′ and 7° 12′ east of Greenwich, and between 50° 45′ and 53° 32′ north latitude. The matter of temperature is illustrated by

FIGURE 1.—In the Westland, the most important fruit section of the province Zuid-Holland, grapes and peaches are the chief fruits and are grown under glass. The picture shows the Naaldwijk district where ½ ha. or more under one glass roof is common.

the following figures from the Dutch meteorological station, average of 1849–1931:

January	2.1° C.	July	18.6° C.
February	3.0	August	18.0
March	5.3	September	15.0
April	9.3	October	10.3
May	13.9	November	5.5
June	17.0	December	2.9

There is no great difference between the various provinces. Winter is mildest at the seaside and in the province of Limburg. In spring the difference between oceanic and continental climate is more conspicuous, which is important for the choice of fruit varieties, which are not all equally early-blooming or equally sensitive in the blooming season. The wind may influence the orchard possibilities adversely. However, no investigations as to the extremes of wind speed are available, and to know the average velocity is of little interest in this connection. Yet it may be said that the sea winds make the westerly Netherlands north of the Hague unfit for fruit growing.

MONTHLY PRECIPITATION IN MM.—AVERAGE FOR 1849–1931

January	47	July	71
February	48	August	80
March	49	September	63
April	43	October	73
May	52	November	58
June	61	December	63

It is evident that the rainfall is heaviest in late summer and autumn, and lightest for winter and spring. Dry seasons do less damage in the Netherlands than in the neighboring countries, because the subsoil water supplies the crops with moisture, except on high land practically never used for fruit.

ORCHARDING SECTIONS

As the map shows, the largest fruit areas are in the southern Gelderland and the adjoining parts of the provinces Utrecht and Noord-Brabant, Zuid-Limburg, Zuid, Beveland, the Westland, and along the Ijssel.

Limburg has a fruit area of 8,688 ha., of which 7,786 ha. are in Zuid-Limburg.

FIGURE 2.—Fruit districts of the Netherlands. Each dot represents 1,000 ha. The most important districts are on the diluvial deposits along the Rhine-arms and on the Loess soil of Limburg.

Here the soil consists chiefly of loess, which owing to its porosity is very favorable for orcharding and, together with the river clay districts along the Maas, constitutes an independent orcharding section, lying on sunny and well protected southern slopes as well as in the river valleys, where many meadows are set out with fruit trees. The climate is here more continental, the air moisture less, and consequently the fruit is less attacked by scab; but on the other hand night frost is more frequent in the blooming season. Night frost and wind damage depend on ground conditions: low sections, protected against the wind, have much night frost, high and flat land is much exposed to the wind.

The high land seldom suffers from too much water, and the summer heat makes itself felt more than in other places. Fruit trees are usually grown in sod here. In the fruit district of this province nearly every family has its own orchard. Apples and pears are the main fruits;

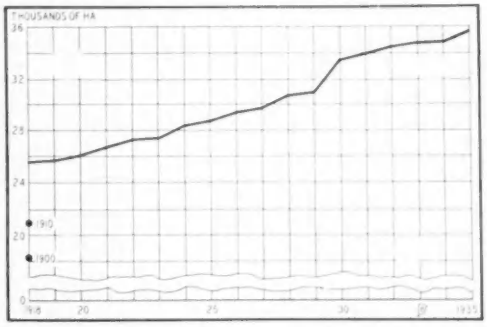

FIGURE 3.—The fruit area of the Netherlands has increased rather unbrokenly from 1918; the years 1929–30 and 1934–35 have the greatest growth. It is now nearly double the area of 1900.

next come plums; less important are grapes and cherries (which, however, are particularly good here). Peaches and red currants are grown to a small extent, while black currants, raspberries, and gooseberries are hardly profitable in this section. Cherries were more important formerly than now. South of Geul there is still a cherry district; Eysdensche cherries from the Maas valley (Eysden) and Basterdikke are varieties very well fit for export because of their thick skin; they are chiefly exported to England.

Noord-Brabant has a fruit area of 4,041 ha. Orcharding is chiefly connected with the river clay district, which (continuing the river clay districts mentioned under Gelderland, Utrecht, and Zuid-Holland) has supplied Amsterdam with fruit since the middle ages. As in Limburg the trees are chiefly grown in sod where young cattle and fowl feed until the fruit-ripening season. Raspberries are and have always been the chief fruit of this province; but they are all consumed in the Netherlands. Next come especially black currants, then apples, and red currants. Pears and gooseberries are of little importance, cherries and peaches of none. Fruit is exported to Belgium and the Ruhr district.

Zeeland's fruit area of 2,443 ha. is located mainly in the western part of the largest island. Apples are the chief fruit grown here, but gooseberries and red currants are also important, among other reasons because they are used as companion crops. About 2,200 ha. are planted with high-headed trees, with bushes as companion crops. Sod culture is rarer here than in other places, because orcharding is an independent industry. Often early apples and pear trees are grown very low-headed like bushes, in the very common "Buschanlage" according to the principle: As much as possible as quickly as possible. Here a fruit grower may subsist on 2½ ha. of land. Also pears are of importance. Less important are black currants, cherries, plums, and raspberries in order. Along the coast the strong winds have made wind-screens a necessary condition for fruit growing.

Zuid-Holland has 2,910 ha. of fruit of which grapes are the most important; next come pears, apples, red currants, and peaches; and all kinds of fruit belonging in the north temperate zone are more or less important.

In the Westland, the most important section, the soil consists of sand and light clay loam. On the sand, flowers are grown, on the clay, fruits. It was here the "ooftteelt" first developed to "fruittuin." With great care people tried to gain the largest possible profit out of the land, and actually almost all old orchards are replanted new. There is a large area with apples, pears, and plums, with red currants as companion crop. The main fruits in the Westland, however, are grapes and peaches, grown in hothouses or cold frames. Here vine-growing in the open air on a south wall has been known for centuries; but about 1850 sloping frames with glass were placed before the plants, and about 1880 this developed into cold frames and later into large hothouses with artificial heating, so that the grapes from this district

became famous as a very early crop. Many of the hothouses are now very large and often continuous with ½ ha. or more under one glass roof. These large houses, however, are never heated. Green and blue grapes are grown together as the green have to be pollinated by the blue to set with fruit. The blue are the best for export owing to their thick skin; the green are consumed in the Netherlands.

In summer daily fast trains carry fruit to Germany. From the district along Nieuwe Waterweg the fruit goes to England by motor lorries via Hook van Holland or by ship via Rotterdam.

Apricots and peaches grown in the open nearly every year suffer from night frost, and their cultivation is hardly profitable. Cherries are not grown, as they demand a rather heavy soil. The river clay district belongs to the above mentioned fruit district that for centuries supplied Amsterdam (sod cultivation).

In the third section, the islands, cultivation of wild cherries (Prunus) is found with bushes under the trees. This is especially characteristic of East Voorne. On the islands in contrast to the Westland there is chiefly outdoor cultivation almost everywhere on clayey soil. Most of the fruit goes to Rotterdam. Little is exported.

Noord-Holland has 1,028 ha. of fruit. Most important are apples and pears, mostly varieties that are not too susceptible to wind and attacks of Fusicladium, grapes and red currants. Less important are gooseberries, black currants, plums, and hazel nuts; raspberries and cherries are not grown. The oldest section here, and still the most important one, is de Bangert (the gooseberry district). Here cultivation of fruit was known as early as the fifteenth century. The fruit has mainly been marketed in Amsterdam after the building of the railroad; recently, however, more and more has been exported, particularly to Germany (apples and pears). The finer varieties of grapes, peaches, pears, and gooseberries go to England. The growing of grapes for export (to England) increases rapidly.

Utrecht has 4,129 ha. of fruit. Just as in the Westland peaches and grapes are the most important fruits, but apples and pears are also very important; next come red currants and gooseberries, plums and hazel nuts. Black currants and raspberries are very little grown, and cherries not at all. The fruit district is mainly the southwesterly part of the province on the river diluvium mentioned before (fruit in grass).

Gelderland's fruit area is 11,056 ha., and the most important fruits are apples and pears but cherries also are very im-

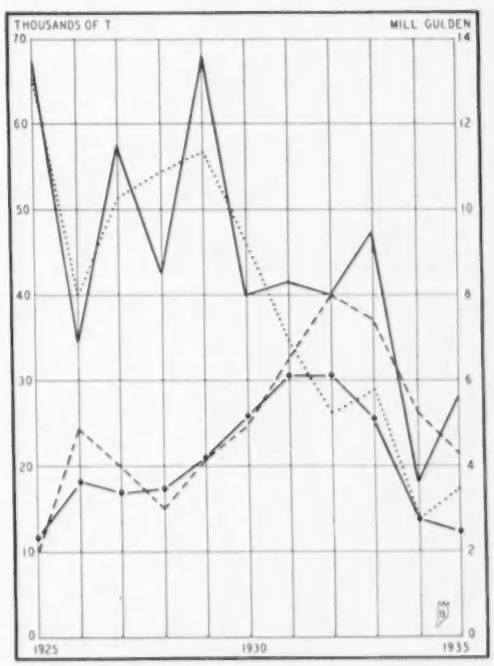

FIGURE 4.—The importance of fresh fruit in commerce with foreign countries. Thick lines represent export, and thin lines, import. The whole lines indicate weight, and the dotted lines, value. Export was greatest in 1925 and 1929, and smallest in 1934. Since 1934 it has been increasing again. Import increased until 1932 and then decreased.

portant. Further, almost every kind of fruit belonging to the temperate zone is grown in varying extent. The most important section of the province, indeed the most important fruit section of the Netherlands, is Betuwe.

For the main section the greater part of the land is devoted to flowers and vegetables, but between them are long rows of cherry trees. Here everybody grows fruit. From this section comes the best fruit and it is easily sold within the country. Difficulties of export are

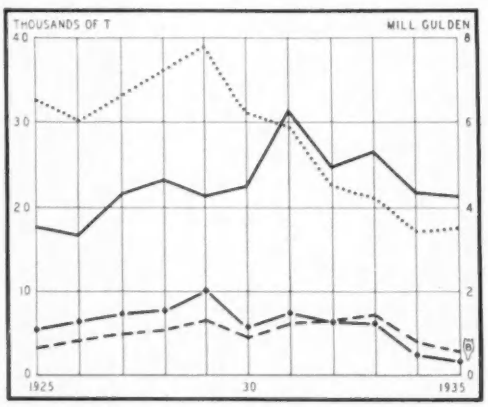

FIGURE 5.—Export (thick lines) of tinned fruit increased from 1925 to 1931 and then decreased. Import (thin lines), which is far smaller, has been nearly constant. The whole lines indicate weight, and the dotted lines, value.

not felt, as can be seen from the rather great increase of the area. It is the fine clay loam of the section that makes the cherries so good; among other things they are used for cherry brandy. Both the red, sour cherries and the yellow, sweet May cherries are grown; the former are ripe in July, the latter in the middle of June.

A little artificial manure is used, for great quantities are needed. Often gooseberries are grown as companion crops between the fruit trees during the first twelve to fifteen years, till there is no longer room for them. A row of apples with rows of cherries alternately is also a common method of growing. The cherries are "fillers" to be removed later unless they prove profitable.

Rather large quantities of fruit are also grown in the river diluvium that for centuries has supplied Amsterdam with fruit (cherries are very important). Here the cultivation is always in sod.

Also the Ijssel district has a great number of orchards, especially with late blooming trees on rather light clay loam, but recently also on sand, which gives only a small profit, particularly at this time. Here, in striking contrast to Betuwe, every class of fruit is grown separately, and orcharding is an occupation for the farmers who will not, or cannot, always give the necessary time to the cultivation and especially to the picking of the fruit, so that the fruit is often sold on the trees. The trees are planted on ploughed land and wire netting is set around them to prevent the cattle from gnawing off the bark. Now almost every peasant in the district has an orchard, large or small.

Apart from the Ijssel district, gardening is very little developed in the East Netherlands, except around large towns that take the garden produce. Along the Ijssel, apples are the chief fruit. Reinettes, Yellow Transparent, and Jonathan are grown mostly on small trees which give the finest fruit. High pear trees are much used for the purpose of breaking the wind, at the same time yielding good fruit. Some varieties of pears suffer less from scab here than farther west. Cherries are hardly ever grown. A great deal of the harvest supplies the canneries; the rest is exported to England and Germany.

Overijssel has 871 ha. of fruit. Here the growing of fruit is of very late importance. The only district of importance is Ijssel, and practically only apples, pears, and very few grapes are grown.

Friesland has 178 ha. of fruit, a de-

cline for the last five years, the conditions for orcharding being rather poor here, and bad times are consequently felt very quickly. Of commercial importance are pears, with gooseberries and red currants as companion crops. Grapes, black currants, peaches, and plums are also grown. Nearly all the fruit is grown in the clay soil in the north of the province, especially near the northwest, whence red and black currants are exported to Hull or London. Some of this fruit goes to Leeuwarden, in the

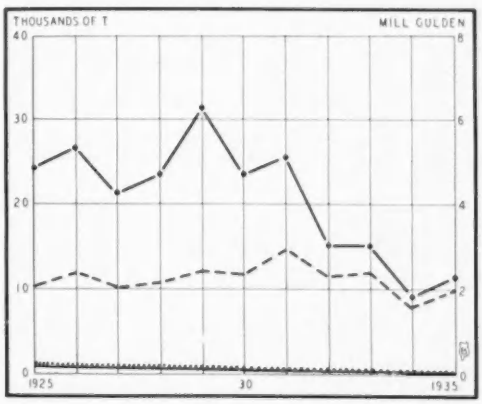

FIGURE 6.—Dried fruit. The thick lines represent export, and the thin lines, import; the whole lines, weight, and the dotted lines, value. Export has diminished more and more; import has not varied much.

neighborhood of which some fruit is grown, but the cultivation here is not specialized, as is the case with most other large towns, and the produce is only meant for the local market. Gooseberries, however, are grown for export.

Groningen has 223 ha., and Drente only 68 ha., of fruit. In these two provinces red currants are by far the most important fruit; next come grapes, black currants (formerly more than now), late blooming pears and apples, gooseberries, plums, and peaches, but practically no cherries. The most important apple varieties are zoete Kroon, which is not diseased at all in Groningen, and Bramleys Seedling. The gardens and hothouses with grapes are nearly always run by peasants. Some grapes are sent to Germany. Fruit grown in the open is in this district almost entirely for private use. Night frost often does considerable damage.

The fluctuation of the total fruit area of the Netherlands appears from the curve. The total area of the Netherlands is stated to be 34 millions of ha.; the fruit area comprises over one per cent of this 35,635 ha., which is about double the area in 1900, when it was given as 18,379 ha. The total area has been steadily increasing, mostly in 1929–30.

CRITICISM OF THE AREA STATISTICS

The total area is obtained by the addition of the areas employed for the cultivation of each particular fruit; in the places where shrubs are used as companion crops the same area is often counted twice. On the other hand where other things than fruit are used as companion crops it cannot be maintained that the whole area is used for fruit. As to hotbeds and hothouses, they are used for long periods of the year for other forms of cultivation, but none the less their whole area is counted as fruit areas. On the other hand vines and peaches on the walls are frequently not counted.

THE VARIOUS FRUITS

By the Dutch word "fruit" is meant all kinds of fruit gathered from trees and shrubs. In the Netherlands melons, tomatoes, pumpkins, and strawberries are considered vegetables.

The statistical material is worked out according to this definition of fruit, and only what comes within this category is included here. As strawberries are elsewhere considered as fruit, it ought to be said that their cultivation is of more importance than any other class of fruit.

Especially during recent years the area for strawberries has increased, mostly in the western districts, and comprises over 2,500 ha.

The cultivation of fruit may be divided into:

A. Open air cultivation
  I. Tree-Fruits
    1. Pomaceous
      a. Apples are principally grown in Gelderland, Limburg and Zeeland, in which provinces they are the principal fruit, but also in Zuid-Holland, Noord-Brabant, and Noord-Holland they are of great importance, while they are less grown in Utrecht, Overijssel (where apples however are the most important fruit, calculated in terms of weight), Friesland, and Groningen. In contrast to most other tree-fruits, especially pears, they thrive very well in boggy soil. The most usual good varieties are Annanas Reinette, Brabantsche Belle Fleur, Goldapples, and Sweet Campagnes.
      b. Pears are second only to apples (considered by weight) in the provinces of Gelderland and Limburg, which are the chief pear-provinces. Also Zuid-Holland, Noord-Holland, and Zeeland have a considerable pear production while the rest of the provinces are less important (in Frijsland, however, pears are commercially the most important fruit). North Dutch Sugar pears, Gieserwildemann, Winerjan, and Omskifikeren are some of the finer varieties.
    2. Drupaceous.—Practically not grown in Overijssel.
      a. Cherries place, as mentioned before, a very great demand on the quality of the soil and demand a rather heavy clay. For this reason cherries are chiefly grown in Gelderland (May-cherries). Besides this province only Zeeland (black cherries), Limburg, and to a small degree Zuid-Holland and Groningen are of any importance. By the Rhine and in Betuwe whence the finest cherries come, their cultiva-

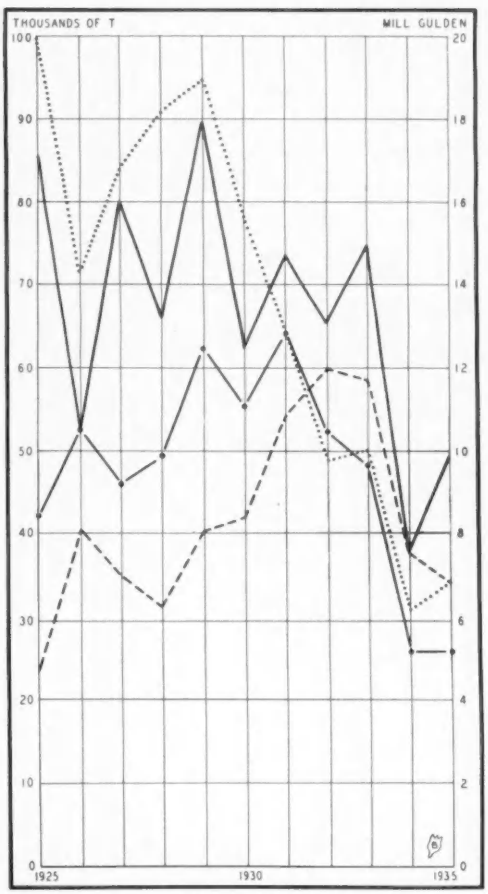

FIGURE 7.—Total export (thick lines) and import (thin lines) of fruit and fruit products. Import increased during the period 1925–32 and then decreased. Export was greatest in 1925, and having varied much in weight (whole lines) and value (dotted lines), it was smallest in 1934.

tion does not seem to be very profitable since the cost of picking has risen so high that it is hardly covered by the market price of the berries.

b. Plums are mainly grown in Gelderland, but also Limburg, Noord-Holland, and Zeeland produce great quantities. They do not seem to thrive in Overijssel.

Groningen, in which last province it is the fruit produced in the largest quantity (by weight).

b. Black currants are grown only in large quantities in Noord-Brabant. Like raspberries, they thrive well in boggy soil, but are now far less important than formerly because of the low prices in England.

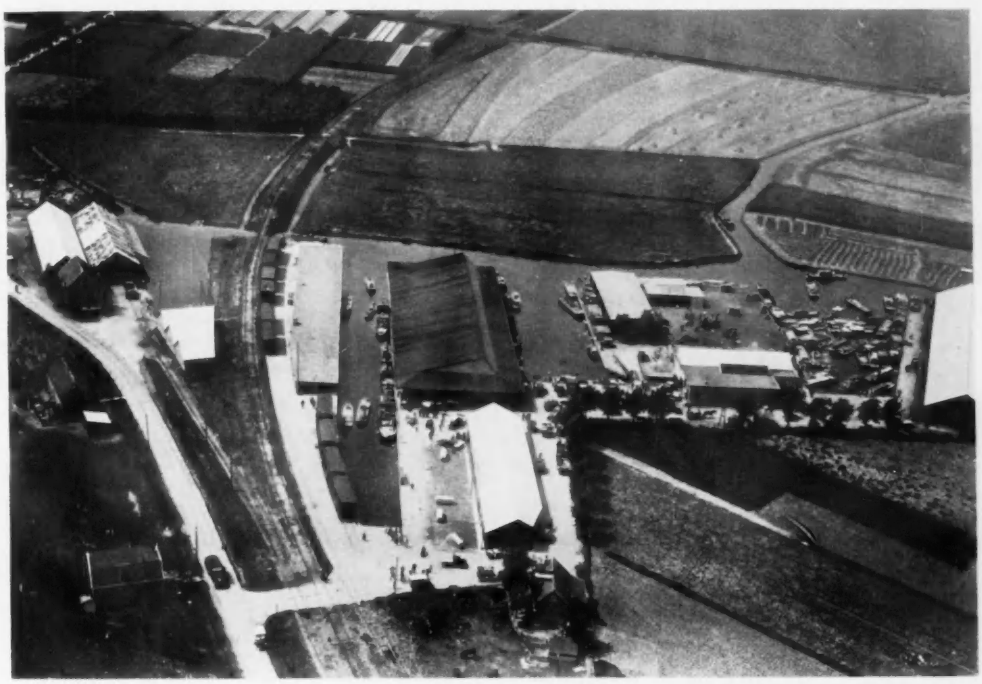

FIGURE 8.—Fruit growers in the Netherlands have united in coöperative unions, "Veilings." Here the fruit is being carried to and from the auction hall of the Veiling "Westerlee" de Lier (in the center of the picture) by ship, cart, and railway.

3. Hazel nuts are grown to a small extent in the southern Gelderland, middle Noord-Holland, West Noord-Brabant, and in Zuid-Holland.

II. Bush fruits—hardly ever seen in Overijssel.

a. Red currants are mainly grown in Zuid-Holland, Zeeland, Noord-Holland, Gelderland, Noord-Brabant, and

Nearly all the export goes to this country. Both the cultivation and the picking demand much more work in proportion to the profit than, for instance, red currants. In a Gelderlandish "proeftuin" (experimental orchard) an experiment in improving black currants to give a greater return is being made.

c. Gooseberries are very important in Zeeland. Also in Gelderland, Noord-Holland, Noord-Brabant, Friesland. The production is of importance but less so in Utrecht and Groningen.

d. Raspberries are grown almost exclusively in Noord-Brabant and are of no importance for export. Nearly all the bushes are diseased (Yellow leaves) and the berries suffer much from worms. In Zeeland also a great many are grown.

B. Hothouse fruit is produced particularly in the province of Zuid-Holland, especially in the Westland.

a. Grapes are the most important fruit in Zuid-Holland, and in comparison with this province the other provinces are of less importance in the matter of grape growing. Of some importance are also Noord-Holland, Utrecht, and Friesland.

b. Peaches and apricots are likewise almost entirely grown in Zuid-Holland. Also the seeds of apricots are used for the production of imitation almond oil.

C. Whortleberries and red whortleberries are not cultivated, and for this reason not counted in the area statistics.

EXPORT AND IMPORT

It may be noted that the weight statistics are given in tons gross. Hazelnuts and walnuts are included with dried fruit. From 1931 also seeds of apricots are put in this category in the official statistics, but as the figures for this product have been kept separate only since 1927 they have been excluded in the statistics upon which the curves for dried fruit and the total export and import are constructed.

Canned fruit includes juice, stewed fruit, jelly, etc. There are several canneries and a number of wine factories, three of which make wine of Dutch grapes.

The statistics include only fruits grown in the Netherlands; but as several of these are grown in such small quantities that the export does not matter as compared with the import, we might with equal right have included oranges which are re-exported in great quantities.

ORGANIZATION

The great increase in the export of fruit is in large part due to excellent organization. Fruit was originally grown for home consumption. But about larger towns orcharding sections developed to supply their needs. Then in Noord-Holland the people began to sell fruit at the inns, and in 1897 some fruit growers united in a "Veiling," a coöperative union. In the following years several other unions were formed, but not until after 1918 did the coöperative movement begin to accelerate notably.

Through the unions almost all the fruit and vegetables are sold; in the Westland everybody belongs to the "veilings" or coöperatives, and contracts to sell his whole production through the coöperatives which also make profitable bargains in fuel, fertilizers, etc., and through their "tuinbouw" consultant give advice and instruction about spraying and grading, so that the fruit may more successfully compete with fruit from other countries.

The "veilings" are united in a central bureau, which among other things takes care of home and foreign propaganda. The different unions are represented in the Netherlandish Council of Horticulture, which manages everything of interest to the trade as a whole.